OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY PROGRAM

PROGRAM AND SPECIFIC OBJECTIVES
DOCUMENT APPROVAL

Jack L. Kerrebrock

Jack L. Kerrebrock
Associate Administrator for
Aeronautics and Space Technology

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Date

PREFACE

The Office of Aeronautics and Space Technology (OAST) is responsible for planning and managing NASA's Aeronautics and Space Research and Technology programs and Energy* Technology program. Broad goals have been established for these programs to assure that they are aligned toward providing the technology required to meet national needs in aviation, space and energy.

The OAST Program and Specific Objectives documents set forth a much more detailed set of objectives (that derive from these broad program goals) which form the basis for planning specific research and technology activities. Separate Program and Specific Objectives documents have been developed for the Aeronautics and Space Research and Technology programs.

The Program and Specific Objectives documents are intended to meet the following management goals:

- o To effectively communicate and describe the OAST programs;
- o To provide management with an integrated viewpoint of an inherently complex and multifaceted R&T program, thereby facilitating the decision process;
- o To force a disciplined approach on near-term detailed planning;
- o To provide a framework from which an orderly evolution of the program can be planned;
- o To facilitate evaluation of the technical feasibility of programs, and to facilitate judgment of the adequacy of our planning;
- o To make the program more result- and accomplishment-oriented.
- o To improve program control by providing each level of management with a clear set of objectives and targets to be accomplished, as well as a set of standards against which progress can be measured;

*Current Energy program is "Reimbursable" only.

- o To make individual researchers/technologists aware of the significance of their output to broad objectives, goals and needs, and to stimulate their imaginations with challenging targets; and

- o To provide a vehicle for implementing the program via solicitation of Research and Technology Objectives and Plans (RTOP) documents from the NASA Field Installations, while allowing the Field Installations maximum flexibility in developing innovative RTOP approaches toward meeting stated objectives and targets.

- o (The RTOP is the vehicle by which an agreement or contract is reached between OAST and a Field Installation concerning the performance and funding of a specific research and technology activity.)

These documents are tools which should be utilized by everyone engaged in planning, managing and performing the OAST programs, to insure that they are fully aware of the purpose of their efforts. It is important, therefore, that these documents, or appropriate parts thereof, be distributed to all levels of the NASA organization involved in the OAST programs.

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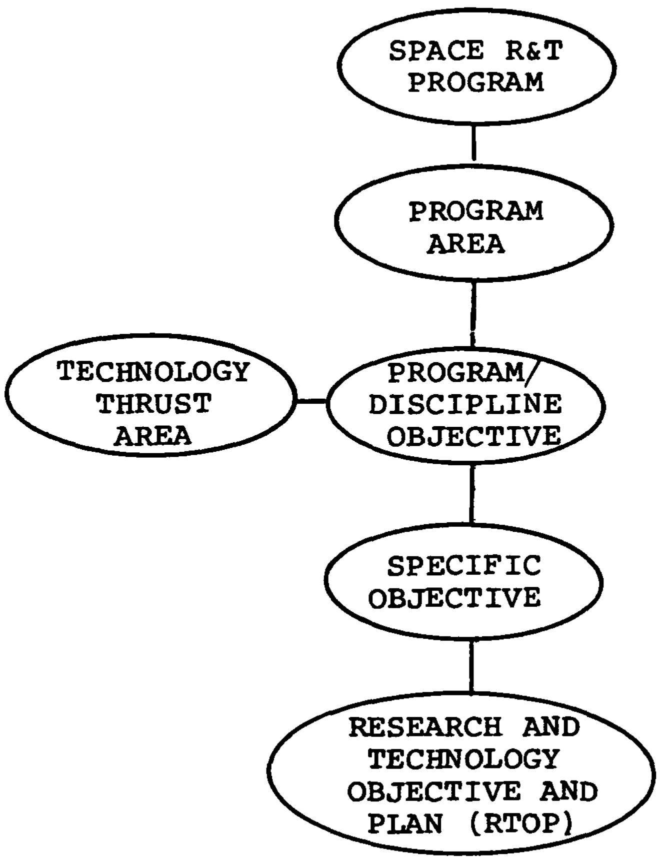
INTRODUCTION

INTRODUCTION

The Space Research and Technology program is broken down into two Program Areas:

- o Research and Technology Base
- o Systems Technology Programs

which are further broken down into succeedingly more detailed activities to form a Work Breakdown Structure for the Space R&T program, as shown in the following chart.



This document provides a detailed view of this Work Breakdown Structure down to the Specific Objective level, and sets forth goals or objectives at each of these levels. It addresses what is to be accomplished and why, but does not address how. The latter falls within the domain of the RTOP, as well as other program documents.

The nature of the Space R&T program is advanced research and technology. The input to the program is the capable effort of highly qualified people, using specialized equipment and facilities, doing theoretical, analytical and experimental work. The output is new technical knowledge. This output is created by OAST to support the future needs of NASA, the DOD, and the private sector in space. Further, the program is highly synergistic, with a given piece of new technology finding broad application by different users to meet different needs. This multiple applicability aspect of the output is fundamental to the structure and management of the Space R&T program.

The Space R&T Program and Specific Objectives document provides goals, objectives and targets in sufficient detail to provide a structure within which Field Installations (Centers) can make decisions concerning RTOP planning and implementation. It is expected that each Center develop and propose a set of RTOP's which fully responds to the objectives and targets set forth in this document, limited only by the roles assigned to that Center by the Agency.

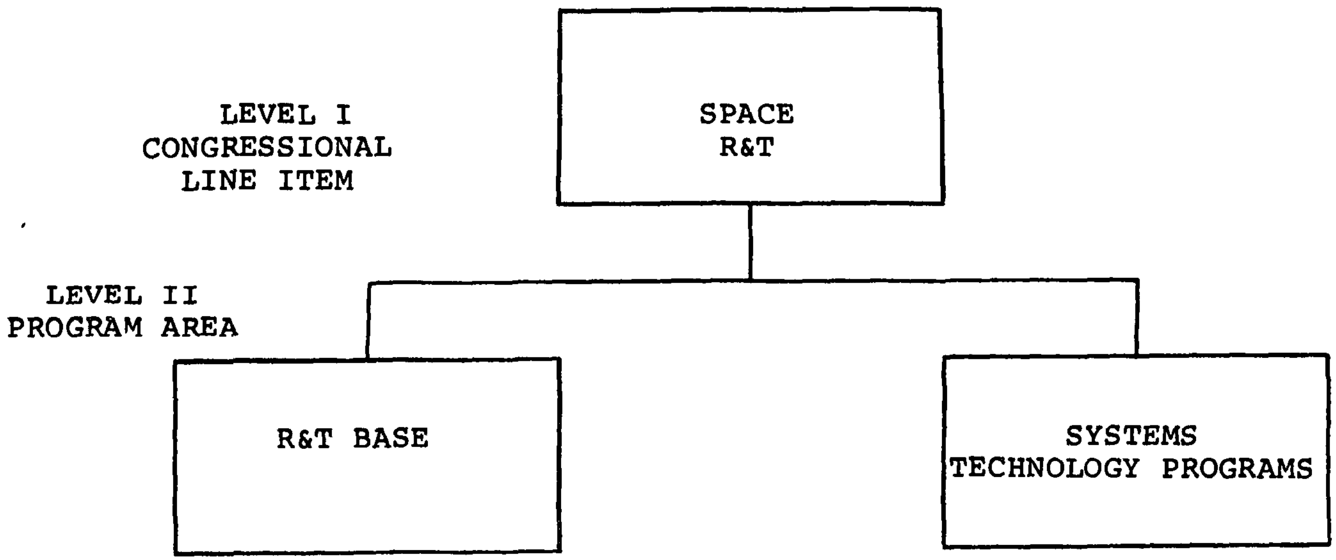
In this document, the Specific Objective narratives provide the lowest level documentation of the program's objectives, and therefore the most detailed. Each RTOP, at a Center, is developed to address a single Specific Objective. The Specific Objective narratives are structured into several parts. First, a short paragraph statement of the Specific Objective is given. This is followed by a bulleted list of thrusts or sub-objectives which delineate the scope of the Specific Objective. A list of targets is then provided for those areas of the Specific Objective that are amenable to a quantitative description of technical accomplishment and schedule. It is important that an RTOP prepared in response to a given Specific Objective address both the thrusts and targets. Finally, a justification statement is included which establishes the need and importance of the Specific Objective.

The targets have been selected to be challenging, but realistic. They may not all be accomplished within the specified time frame. The research and technology process is characterized by an unpredictable path that can result in failure. However, it is recognized that the researchers/technologists are at their best, when they are seriously committed to achieving a set of targets.

SPACE RESEARCH AND TECHNOLOGY

SPACE R&T WORK BREAKDOWN STRUCTURE

LEVELS I AND II



PROGRAM GOAL

TITLE: Space Research and Technology

PROGRAM GOAL:

To provide a technology base which will adequately support current activities and enhance and/or enable future activities involved in the exploration and exploitation of space.

PROGRAM AREA GOALS:

- o Research and Technology Base: To establish and maintain a solid foundation of technology embracing all of the disciplines and areas of systems research associated with space, and to provide a wellspring of ideas for advanced concepts.

- o Systems Technology Programs: To provide technology for systems which have matured under the Research and Technology Base; to carry the innovative systems through experimental testing and verification in a realistic environment; to design, fabricate and test multidisciplinary concepts in the space environment, thereby reducing the technical risk and qualifying the technology concept for use on future missions; and to develop major research payloads for future missions.

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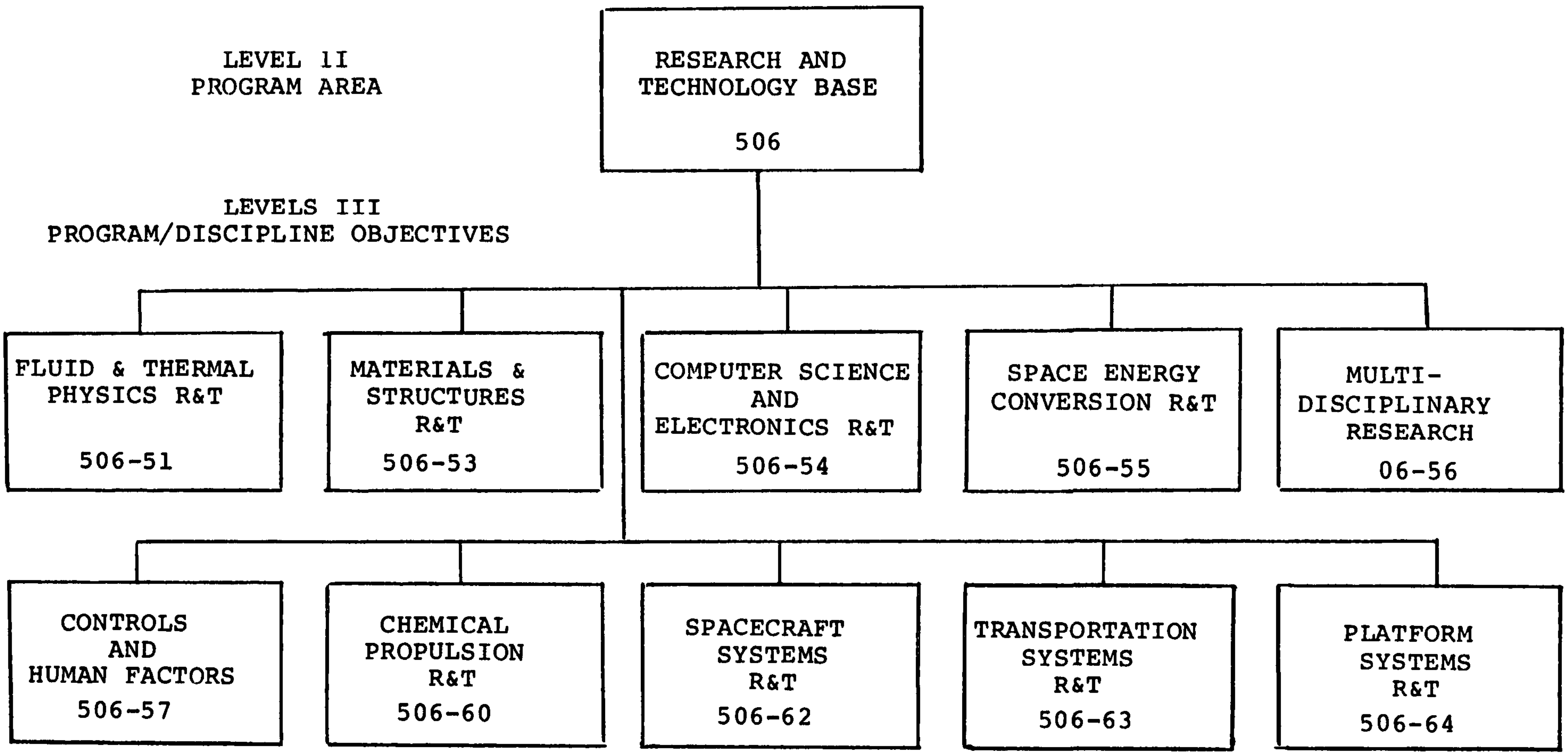
RESEARCH AND TECHNOLOGY BASE

SPACE R&T BASE WORK BREAKDOWN STRUCTURE
LEVELS II & III



PROGRAM AREA GOAL

TITLE: Research and Technology Base

Program Goal Title: Space Research and Technology

PROGRAM AREA GOAL:

To establish and maintain a solid foundation of technology embracing all of the disciplines and areas of systems research associated with space, and to provide a wellspring of ideas for advanced concepts.

PROGRAM/DISCIPLINE OBJECTIVES:

- Fluid and Thermal Physics R&T: To advance the understanding and capability to predict fundamental aerothermodynamic phenomena to permit optimization of advanced aerospace vehicles in the early stages.

- Materials and Structures R&T: To provide advanced materials and structures technology that will allow the development of future space systems with significant improvements in performance, durability and economy. Major emphases are given to advancing the state of the art of structural concepts and advanced materials applications for large-area space structures, spacecraft, and advanced space transportation systems.

- Computer Science and Electronics R&T: To provide the fundamental electronics and computer science and technology base to advance theory and provide electronic device, detector, automation, computational and software technologies needed to enable future space systems; to provide the techniques and technologies required for the acquisition, processing, reduction, and distribution of space-acquired data on a real-time basis for experimental, scientific and operational space vehicles and station in the 1990-2000 time frame; and to provide the advanced high-risk microwave and optical communications technology to support the future needs of NASA, other government agencies and the private sector, and to insure the continued U.S. preeminence in satellite communications.

- Space Energy Conversion R&T: To provide the technology basis for future space power and electric propulsion.

- Multidisciplinary Research: To conduct basic research of scientific and engineering interest to advanced space technology.

- Controls and Human Factors R&T: To provide advanced controls and guidance technology and human factors principles that will allow the design of future space vehicles, platforms, and other spacecraft with significantly improved performance, endurance and operational efficiency, or with increased mission capability. The program is to develop fundamental understanding and design analysis methodology, as well as focused disciplinary research specific to space transportation, spacecraft, and space station requirements.

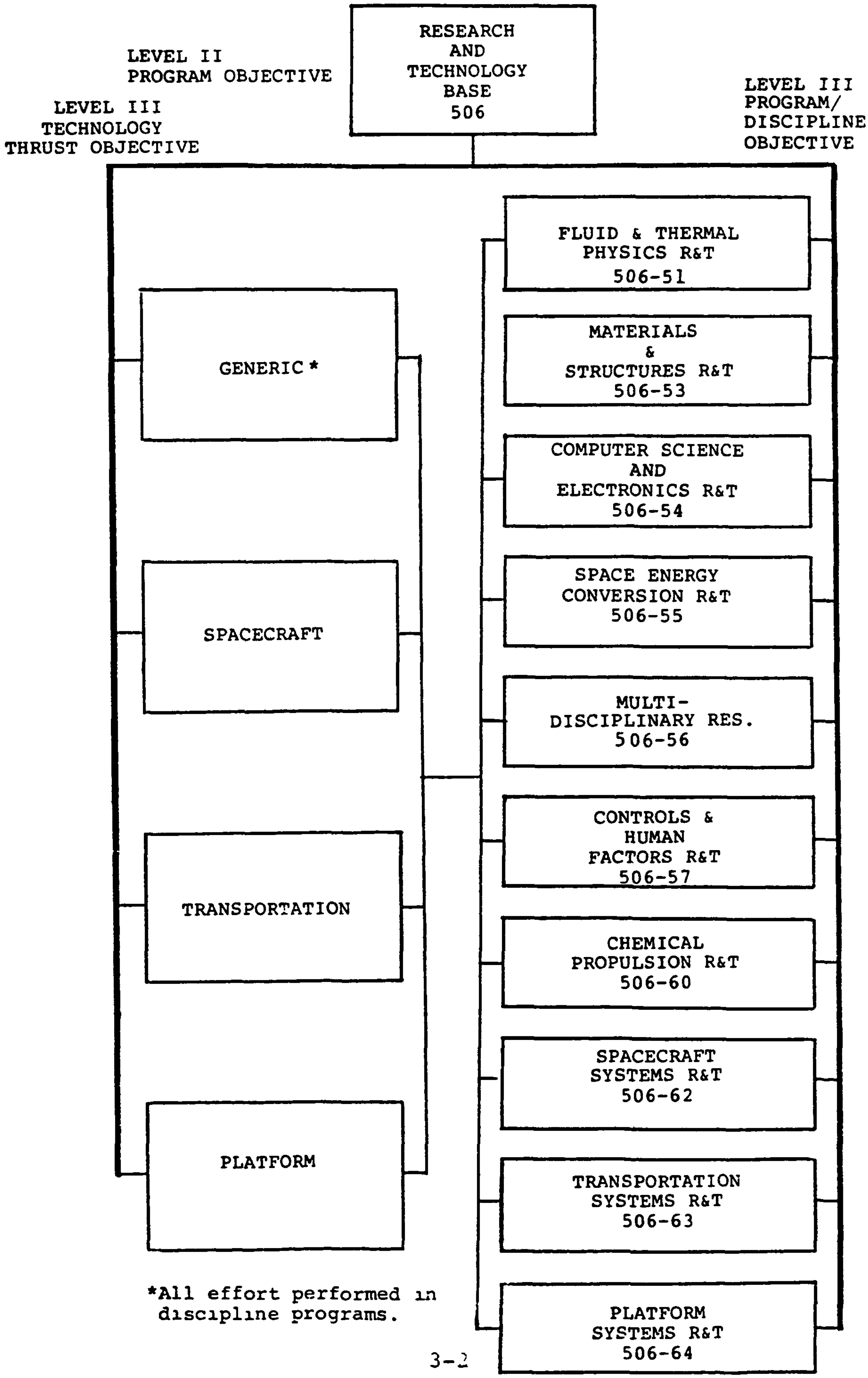
- Chemical Propulsion R&T: To provide the propulsion research and technology base for lower cost reusable Earth-to-orbit space transportation systems; for long-life Earth-orbiting spacecraft and platforms; and for more versatile and higher performing orbital transfer vehicles.

- Spacecraft Systems R&T: To develop and provide spacecraft technology for large space antenna systems and advanced Earth orbital and planetary spacecraft to support the nation's commercial and scientific objectives in space. This objective is accomplished by identifying spacecraft mission requirements; carrying out system studies, analysis, trades, and simulations; establishing goals and generating discipline and system technology programs requiring analysis and ground and space experiments.

- Transportation Systems R&T: To identify the technology requirements for advanced transportation vehicles to satisfy national needs and then to integrate these requirements into a comprehensive plan that results in transfer-ready technology at the proper time; to advocate the research and technology programs to satisfy these requirements; to conduct the system-level technology programs; and to support the development of the space transportation system (STS) in areas of technical competence. These objectives are accomplished through system-level studies, analyses and requirement definition efforts, discipline and system R&T efforts requiring ground-based facilities, in-space hardware, and instrumentation. Some efforts utilize the Orbiter as an advanced research vehicle.

- Platform Systems R&T: To identify the technology requirements and conduct systems and discipline advanced technology programs that support Agency platform and space station thrusts for permanent occupancy of space. To provide integrated system and discipline programs that maximize technology options, allow for modular evolutionary growth capability with new technology and satisfy national needs for improved performance missions while minimizing life cycle costs. To establish a coordinated technology program across all disciplines that will produce appropriate levels of transfer-ready technology phased with mission needs. To identify and define requirements for ground and in-space tests and experiments including facilities, instrumentation, and hardware/software to validate system and discipline performance and analytical methods.

R&T BASE MATRIX STRUCTURE



*All effort performed in discipline programs.

SPACE R&T BASE MATRIX MANAGEMENT

The Space Research and Technology Base program is divided into two Level III sections -- Technology Thrust Areas and Discipline Technologies.

The Technology Thrust Areas describe the research and technology program from the perspective of the three major system-oriented elements of the program (Spacecraft Systems, Transportation Systems, and Platform Systems), and the narrative for each includes both the Specific Objectives for the system-level work and a top-level description of the applicable discipline work.

The Discipline Technologies describe the program from the perspective of the discipline categories (Fluid and Thermal Physics, Materials and Structures, Computer Science and Electronics, Controls and Human Factors, Space Energy Conversion, Chemical Propulsion and Multidisciplinary Research), and the narrative for each includes the Specific Objectives for the overall discipline program. In addition, the discipline objective statements are followed by thrust statements in each of four categories (Generic, Spacecraft, Transportation and Platform) which provide additional focus for the research and technology efforts. The system-oriented thrusts resulted from discussions between the system-level managers in the Space Systems Division and the discipline managers in the Aerospace Research Division. These elements of the discipline statements provide additional visibility from the perspective of the vertical-cut (or system categories) as outlined in the enclosed figure depicting the matrix management relationships within OAST.

The vertical-cut management function is provided by the appropriate offices in the Space Systems Division for the Spacecraft, Transportation and Platform systems categories and by the Aerospace Research Division for the Generic research category. These organizations provide the focal points for establishing the broad research and technology requirements and plans within the vertical-cut categories through interaction with the NASA user offices, industry and special advisory committees. The accomplishments of the program will be reviewed from both the discipline and vertical-cut perspectives prior to establishing program objectives and budget guidelines for FY 1984.

As in previous years, the research and technology program is described in the Specific Objectives and their supporting targets, and the RTOPs should be written against them. The management of the Specific Objectives is also unchanged. The principal point of contact will continue to be the Discipline program managers for the Discipline work and the Systems program managers for the system-level work.

The complementary aspects of the discipline/system and vertical-cut management functions should provide more effective support of the Agency's Space R&T program.

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SPACE R&T PROGRAM
MATRIX MANAGEMENT RELATIONSHIPS

DISCIPLINES/SYSTEMS	TECHNOLOGY THRUSTS			
	Generic	Transportation	Platform	Spacecraft
Fluid and Thermal Physics R&T	X	X	X	
Materials and Structures R&T	X	X	X	X
Computer Science and Electronics R&T	X	X	X	X
Controls and Human Factors R&T	X	X	X	X
Space Energy Conversion R&T	X	X	X	X
Chemical Propulsion R&T	X	X	X	
Multidisciplinary Research	X			
Transportation Systems R&T		X		
Spacecraft Systems R&T				X
Platform Systems R&T			X	

TECHNOLOGY THRUST AREAS

TECHNOLOGY THRUST OBJECTIVE

TITLE: Spacecraft Technology

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

TECHNOLOGY THRUST OBJECTIVE:

To develop and provide spacecraft technology for large space antenna systems and advanced Earth orbital and planetary spacecraft to support the nation's commercial and scientific objectives in space. This objective is accomplished by identifying spacecraft mission requirements, carrying out system studies, analysis, trades, and simulations, establishing goals and generating discipline and system technology programs requiring analysis, and ground and space experiments.

SPECIFIC OBJECTIVE:

- o Spacecraft Systems Analysis: Carry out systems studies, analyses, trades, and simulations for advanced Earth-orbital satellites to support NASA applications, DOD, and high-risk commercial ventures in space; to support large space antenna systems suitable for mobil communications, very long baseline interferometry and radiometry; to support precision deployable structures suitable for submillimeter, infrared (IR) and other large optical systems; and to support planetary aerocapture missions.

- o Spacecraft Technology Experiments: Conduct ground and flight system experiments for antenna systems and advanced spacecraft and develop Shuttle space test facilities.

SUPPORTING DISCIPLINE OBJECTIVES:

- o Materials and Structures R&T

  Provide materials and structures technology to develop advanced structural/thermal material for long life operation in the space environment; to develop advanced deployable and erectable structural concepts for stiff and flexible spacecraft configurations to develop structural dynamic prediction and characterization methods

and loads criteria for large, nonlinear flexible spacecraft; and to develop integrated analysis and design techniques and advanced mechanisms.

- Provide materials for structural and thermal applications and mechanisms/moving parts that are dimensionally stable for greater than 10 years exposure to the space environment at Low Earth Orbit (LEO) and Geostationarly Earth Orbit (GEO)

- Develop advanced structural concepts and loads criteria for design, for large lightweight space antennas suitable for communication, very long baseline interferometry, and for radiometry systems; for precision deployable/erectable structures suitable for IR/submillimeter and other large optical systems, and advanced Earth orbital spacecraft structures.

- Conduct ground testing for large space antennas characterizing structural performance for application to generic large antenna systems.

- Develop analytical methods and techniques to characterize non-linear structural dynamics and dynamic interaction/response to disturbances. Develop damping and vibration suppressive/isolation techniques.

- Develop, design, and evaluate high reliability mechanisms for deployable/retractable structures and for construction, assembly, maintenance, and servicing.

- Develop integrated analysis/design tools for structure/thermal/control analyses. Develop new or improved analytical optimization techniques for multidisciplinary analysis.

o Computer Science and Electronics R&T

Electronics

To investigate and advance new and existing scientific concepts and phenomenology necessary for the development of electromagnetic devices, materials, and sources required to enable NASA

thrusts and missions. To discover, develop, and evaluate new electronic and optical concepts for improved sensing capability, higher information and data transfer and storage, and real-time signal processing and controlling. To explore new and noval concepts for the implementation of advanced solid-state technology for application in the unique space environment.

Sensors

To investigate, design, develop, and test innovative experimental systems that exploit the unique properties of lasers and the capabilities of microwave tubes for the passive and/or active remote sensing of terrestrial, planetary, and galactic environments. To investigate, develop and test infrared detectors technology to enable future NASA scientific and application missions. To conduct research and development in the area of low and ultra-low temperature refrigerator concepts for sensor and instrumentation cooling in space.

Data

To provide the technology and techniques for the acquisition, processing, reduction, and distribution of data on a real-time basis from experimental, scientific, and operational spacecraft in the 1985-2000 time frame.

- Develop and demonstrate an onboard spacecraft capability for adaptive control, processing, and handling of high-speed sensor data. The system will provide onboard data control, calibration, data set selection, and processing, and will include data storage, high-speed computer systems, and fault tolerance.

- Improve the performance of the command and control process while reducing labor intensive costs by developing automated command generation capabilities, and modeling and demonstrating command and control system designs with onboard functional command capability.

- Build a massively parallel image processing system that will perform logical operations at a rate of 10^9 operations per second and a real time ground based SAR processor.

Communications

To provide through research, design, and experimental tests, the components and technology needed to support NASA's communication technology program aimed at insuring continued U.S. pre-eminence in satellite communications. The activities encompassed by this research and development program focus on the critical, long lead-time, high-risk components, techniques, and subsystems which are required for communications satellite systems. They also include systems and component technology for NASA's future Earth-orbital payloads and deep space missions.

- Design and develop high-efficiency, high-power microwave amplifiers from 1 to 100 GHz for NASA communications applications using traveling wave tubes (TWT), klystrons, and fast wave devices.

- Develop GaAs Monolithic Microwave Integrated Circuit (IC) transmit and receive technology for lightweight, efficient 20 and 30 GHz scanning beam systems.

- Develop technology for intersatellite link applications.

- Advance switched and scanned multibeam antenna and feed technology for wideband and narrowband concepts for greater sidelobe reduction and improved beam isolation.

- Design and develop low-noise solid-state receiver and solid-state transmitter amplifers for space systems.

Automation

To provide technology for improving the functionality and cost effectiveness of spacecraft systems and operations, leading ultimately to spacecraft autonomy, through the development and application of artificial intelligence and related techniques.

- Improve the performance of the command and control process while reducing labor intensive costs by developing automated command generation capabilities, and modeling and demonstrating command and control system designs with onboard functional command capability.

o Controls and Human Factors R&T

To advance the understanding and state of the art of controls, precision pointing, and stability and guidance and navigation of large Radio Frequency (RF) antennas, precision reflectors, and advanced Earth orbital spacecraft.

- Carry-out analytical and experimental controls technology development suitable for large lightweight antennas which must be pointed and stabilized in space for prolonged periods of time and for precision deployable/erectable reflectors requiring active figure control.

- Provide controls experiment definition support to Shuttle antenna experiment and beam flight experiment.

- Develop sensor technology for fine image stabilization by offset stellar guidance to milli-arc-second tolerance.

- Develop technology for solid-state guidance and navigation sensor.

o Space Energy Conversion R&T

Provide through research, design, and experimental tests the advances in power systems technology that will enable higher specific power, lower cost, and long lifetime power systems for future Earth orbiting and planetary spacecraft.

- Develop high-energy-density batteries for LEO/GEO application that will provide a high cycle life energy storage system.

- Determine, select, and develop solar cell, blanket, and array technologies that will provide the capability for a low-cost, long-life photovoltaic energy source for Earth-orbiting missions in HEO/GEO and for future planned planetary missions, emphasis to be directed to requirements of High Earth Orbit (HEO)/Geostationary Earth Orbit (GEO) missions.

TECHNOLOGY THRUST OBJECTIVE

TITLE: Transportation Technology

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Edward A. Gabris

TECHNOLOGY THRUST OBJECTIVE:

To identify the technology requirements for advanced transportation vehicles to satisfy national needs and then to integrate these requirements into a comprehensive plan that results in transfer-ready technology at the proper time; to advocate the research and technology programs to satisfy these requirements; to conduct the system-level technology programs; and to support the development of the space transportation system (STS) in areas of technical competence. These objectives are accomplished through system-level studies, analyses and requirement definition efforts, discipline and system R&T efforts requiring ground-based facilities, in-space hardware, and instrumentation. Some efforts utilize the Orbiter as an advanced research vehicle.

SPECIFIC OBJECTIVES:

- o Systems Analysis: To project and characterize future space transportation needs and capabilities encompassing Earth-to-orbit, orbit-to-orbit, and planetary missions; to conduct technology assessments to identify, justify, and prioritize high-leverage enabling and enhancing technologies; and to provide scope and direction for the R&T program in space transportation.

- o Orbiter Experiments Program (OEX): To obtain data on the characteristics of space transportation vehicles which cannot be satisfactorily obtained by analytical techniques using models and computer codes or experimentally in ground-based facilities (such data will be obtained from existing Shuttle flight instrumentation or by special instrumentation developed and integrated into the Orbiter by this program), and to verify the characteristics of advanced transportation hardware in the actual environment to minimize the risk of technology transfer to the flight program.

SUPPORTING DISCIPLINE OBJECTIVES:

- Fluid and Thermal Physics R&T

  Develop a technology base which will provide weight and cost reductions, and improved performance, in the design of existing and advanced transportation systems.

  - Provide analyses of the aerodynamic and aerothermodynamic flight data from the Space Shuttle System and orbiter experiments (OEX) with emphasis on enhancing the flight data base required to improve existing and advanced transportation system configurations.

  - Provide analyses of aerothermodynamic and aerodynamic performance characteristics of advanced ETO and entry transportation system configurations.

  - Provide analyses of aerothermodynamic and aerodynamic performance characteristics for optimized trajectories of aeroassisted orbital transfer vehicle configurations.

SUPPORTING DISCIPLINE OBJECTIVES

- Chemical Propulsion R&T

  Expand the technology base for liquid rocket propulsion systems with emphasis on improvements in engine life, durability, and the ability to quickly predict/diagnose/repair engine problems in addition to increasing performance. For ETO applications, two main thrusts are to be maintained: the first uses the current Shuttle engine as a baseline from which high-pressure O_2/H_2 engine technology can be undertaken to extend subsystem reliability, life and performance; the second thrust, although less critical at this time, is technology in O_2/HC propulsion for a potential engine requirement in the 1995-2005 time frame. For orbital transfer propulsion, a strong technology base for a high-performance (1990 IOC) O_2/H_2 engine to satisfy GEO payload delivery missions in excess of 10,000 lbs. including manned sortie missions. Operational scenarios for this advanced engine dictate a highly versatile concept to accommodate reuse, space basing, aeroassist, and low-thrust operation.

  - Follow the primary high-pressure O_2/H_2 propulsion technology plan developed by the inter-center working group with provisions for changing/adding tasks as requirements dictate.

  - Develop an OTV O_2/H_2 propulsion technology plan with emphasis on the postulated mid-1990 requirement for a space-based, reusable, aeroassisted vehicle that could grow to a manned transfer vehicle.

  - Continue the technology program for a dedicated low-thrust ($\approx$500 lbs.) OTV O_2/H_2 engine (as opposed to integral spacecraft propulsion) to preserve the option to respond to a future OTV application requirement.

  - Develop analytical modeling capabilities to determine and quantify sensitivities between key engine parameters in terms of system performance, reliability, life, and life cycle costs, i.e., the relative benefit and cost of advancing specific subsystem technologies.

- Develop methodology, including laboratory tests, to characterize OTV engine plumes and their potential effects; this knowledge will become extremely important in space basing scenarios. As this activity is also of interest in other Aerospace Research Division areas, examine the potential of consolidation under one office.

- Establish flight requirements (OEX) in support of the Chemical Propulsion program. This activity should include program/concept definition studies for flight and related ground-based activities, definition of data analysis requirements and development of analytical tools.

SUPPORTING DISCIPLINE OBJECTIVES:

- Materials and Structures R&T

  Expand the basic understanding of the nature and behavior of materials when exposed to the space environment; investigate, develop, and test high-temperature (600°F) composites for lightweight primary structures and develop processing concepts and techniques to minimize their manufacturing costs; develop ceramic, advanced carbon-carbon, and metallic thermal protection system (TPS) concepts for increased durability and reduced weight; develop and validate concepts for integral (internal) cryotankage systems; and develop nonlinear thermal/structural analytical and test methods and techniques.

  - Determine the importance of high-temperature composites for advanced transportation systems and the relevance of the OAST R&T program to the national effort.

  - Establish a plan to have the Shuttle Project Office assume support of very near-term ceramic TPS requirements specifically, such activities as pilot plant demonstrations of new materials/concepts.

  - Validate the use of thin-section advanced carbon-carbon (ACC) panels for TPS applications including an OEX flight demonstration. Work in metallic TPS should be pursued in support of advanced vehicle concept studies. Blanket TPS technology activities should focus on emissivity and waterproofing issues.

  - Develop external-tank TPS alternative concepts and determine their potential; if cost-effective, define an appropriate technology program.

- Support the advanced ETO system studies with integral cryotankage concepts. Develop advanced OTV tankage systems compatible with the constraints imposed by long-term cryogenic propellant storage and space debris protection requirements.

- Develop a program to support the needs of an advanced OTV which will use aeroassist for recovery and maneuvering.

- Develop thermal/structural analytical methods to effect reductions in the costs of integrating spacecraft into transportation vehicles.

- Establish OEX flight requirements in support of the Materials and Structures program; perform program/concept definition studies for flight and related ground-based activities; establish data analysis requirements; and support the development of data analysis tools and the utilization of flight and ground-based data.

SUPPORTING DISCIPLINE OBJECTIVES:

o Controls and Human Factors R&T

Develop the technology base for advanced guidance and control systems for current and future transportation systems. For ETO vehicles, utilizing the current Orbiter as a performance baseline, develop technology to facilitate and enhance system control during payload deployment and retrieval and when bodies are attached to the Orbiter. Develop technology to improve flight control data processing systems by incorporating distributive fault-tolerant design architectures. For OTV vehicles, two critical technology needs are to be addressed for system needs in 1990: active guidance and control for aeromaneuvering and autonomous guidance and control for rendezvous and docking.

Develop the technology base in human factors for a manned OTV system which is expected to become operational in the mid-1990's. Advanced human factors technology may also have application opportunities with subsequent Orbiter procurements (post OV-105). A second-generation ETO launch system (IOC post-2000) will be human-factors configured.

- Follow the recommendations of the Space Vehicle Guidance and Control Working Group to establish and prioritize a technology development program. Cognizance of the priorities delineated in the final report should be maintained with appropriate flexibility as requirements and emphasis change.

- Maintain awareness of the OTV Aeroassist Working Group activities recognizing that they will be identifying guidance and control technology requirements (most probably for FY 1984 initiation).

- Establish flight requirements (OEX) in support of the Controls program. This activity should include program/concept definition studies for flight and related ground-based activities, definition of data analysis requirements, and development of analytical tools.

- For crew/vehicle interaction, develop methods and techniques for using advanced display and control technology (e.g., flat panel displays, touch-sensitive panels, voice recognition synthesis, etc.) for developing more efficient vehicle crew-station designs. Develop techniques for integrating multifunction display requirements into advanced graphic/alphanumeric display control systems.

- Develop an anthropomorphic data base capability for crew-station layout design which can be applied to ETO and OTV vehicle applications.

SUPPORTING DISCIPLINE OBJECTIVES:

- Computer Science and Electronics R&T

  Develop methodology and architecture for advancing and applying automation technology to current and future space transportation systems-- the primary goal being to improve overall mission efficiency with attendant reductions in life-cycle costs. In this activity, technology development should focus on automating mission planning, scheduling, and control functions and on vehicle subsystem management to include incipient failure detection, isolation, and repair.

  In the area of electronics, prime emphasis should be placed upon the identification of electronics technology which can benefit space transportation applications. This activity should be particularly sensitive to methodologies and components for advanced fault-tolerant data processing, storage, and display systems.

  - Enhance fault detection, isolation, and recovery (FDIR) technology at the line replaceable unit (LRU) level for current and advanced space transportation systems.

  - Demonstrate the advanced bubble-memory technology, which promises more reliable and cost effective data storage, in a space transportation system application. Develop a plan to fly a bubble-memory experiment on a Shuttle flight.

SUPPORTING DISCIPLINE OBJECTIVES:

- Space Energy Conversion R&T

  Investigate alternative high performance propulsion concepts and determine their applicability to future orbital transfer systems. Develop technology to support efficient and mission effective power subsystems for advanced transportation systems.

  - Achieve an efficient archival of the mercury ion thruster state-of-the-art technology in FY 1983

  - Initiate an assessment of the technology opportunity for an advanced OTV power subsystem (IOC in the 1990-1992 time frame).

TECHNOLOGY THRUST OBJECTIVE

TITLE: Platform Technology

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

TECHNOLOGY THRUST OBJECTIVE:

To identify the technology requirements and conduct generic systems and discipline advanced technology programs that support Agency platform and space station thrusts for permanent occupancy of space. To provide integrated system and discipline programs that maximize technology options, allow for modular evolutionary growth capability with new technology and satisfy national needs for improved performance missions while minimizing life cycle costs. To establish a coordinated technology program across all disciplines that will produce appropriate levels of transfer ready technology phased with mission needs. To identify and define requirements for ground and in-space tests and experiments including facilities, instrumentation, and hardware/software to validate system and discipline performance and analytical methods.

SPECIFIC OBJECTIVES:

- Systems Analyses: To perform systems analysis and interdiscipline interaction/sensitivity studies to define technology drivers and priorities for high-leverage discipline technology programs. To develop systems analysis/optimization techniques across disciplines and systems configurations for evolutionary modular growth with advanced technology. To define and develop technology for automated system self-test/monitoring, environment interaction and crew escape and rescue.

- Operations: To provide operations technology to support on-orbit construction/assembly, checkout, rendezvous, docking and proximity operations, logistics, and maintenance and servicing. To define automation requirements and automated systems to optimize space and ground operations and provide capability for evolutionary systems growth.

- Crew/Life Support: To develop crew and life support water regenerative and air revitalization technology to establish permanent human presence in space.

SUPPORTING DISCIPLINE OBJECTIVES:

- Fluid and Thermal Physics R&T

  Provide the computational techniques needed to predict contamination and aerodynamic performance impacts of a Low Earth Orbit (LEO) space station.

  - Investigate impact of contamination due to propulsion exhaust products from nearby vehicles.

  - Provide analysis of space station configurations, aerodynamic performance and interaction with rarefied Earth atmosphere.

- Chemical Propulsion R&T

  Provide on-board chemical propulsion technology for drag makeup and attitude control for large space systems in LEO.

  - Develop technology for low-thrust propulsion system (25 to 500 lbs.).

- Materials and Structures R&T

  To advance the understanding of materials behavior in space and develop advanced space-durable materials. To develop advanced structural concepts, load and design criteria, prediction methods for structural dynamics, and integrated analysis and design tools.

  - Develop analytical and experimental methods to characterize thermal and dimensional stability and lifetime of materials in the space environment.

  - Develop advanced long-life durable debris-resistant materials that are thermally and dimensionally stable and insensitive to long- and short-term exposure to the varying space environment, with optimum strength, stiffness, weight, and damping characteristics.

- Develop integral structures/thermal control coatings and durable/maintainable surface thermal control coatings.

- Define and develop advanced deployable, erectable and assembled structural concepts that are optimized for launch and on-orbit loads, packaging, utility and subsystem integration, dynamics and control, deployment, reliability, damping, and modular evolutionary growth. Develop vibration suppression isolation techniques.

- Develop and validate advanced spacecraft analysis and synthesis methods and techniques for design and prediction of non-linear structural dynamics, systems identification, integrated/interactive structural analyses, vehicle dynamics/loads, and structural optimization analysis techniques. Develop techniques and procedures for modular structures characterization.

- Develop and validate methods, techniques, and prediction capability for optimization of on-orbit construction and structural assembly. Define and develop hardware mechanization.

- Define, develop, and characterize mechanisms to be used with the structural system for deployment/retraction, etc., for actuation, drives, etc., for use in on-orbit construction assembly, maintenance, and servicing.

o Computer Science and Electronics R&T

To develop advanced data systems architectures and components for on-board and ground acquisition processing storage and distribution of information that provides for evolutionary growth capability with system and subsystem autonomy. To develop technology for automation and robotic systems and teleoperators. Develop communication, navigation, and tracking technologies.

Data

- Develop and demonstrate overall data system architecture for operational space station of the mid-1990's to allow the evolution in electric and optical processing technology and the incorporation of advanced subsystems in growth configurations. Provide for system autonomy as a key element in the system architecture that allows modular growth and on-orbit autonomous operation.

- Develop and demonstrate fault-tolerant onboard processing and handling capability for adaptive control processing and handling of high-speed data. Develop technology for high-speed data bus and interface electronics components and provide information networking systems concepts and protocols.

Automation/Robotics

- Develop the fundamental technology for full sensory feedback (including visual and tactile) integrated with machine intelligence for fully automatic operation of multi-arm manipulator systems.

- Develop methodology and simulation capability and demonstrate algorithms for direct control, supervisory control, autonomous control and local intelligence in teleoperator and robotic systems.

- Develop the technology base for an experimental telepresence system which out performs direct human manipulation.

- Develop basic expert system technology capability and identify utilization for space station and operations.

Communications

- Determine space station communication requirements and develop the technology required to enable multiple simultaneous communication links including space-to-Earth, intersatellite, intrasatellite, and proximity links.

o Controls and Human Factors R&T

Controls

To advance the understanding and state of the art in pointing and stabilization of large systems controls, multibody guidance and controls and advanced guidance and control devices.

- Develop analytical and experimental techniques for control of modular bodies, advanced control for manned space stations, advanced system identification, multiple payload interactive systems, adaptive control techniques for flexible spacecraft, model order estimation and compensation, control of distributed systems and shape determination systems.

- Develop techniques for momentum management of platforms, space platform control technology verification, experiment controls testing facilities for large space systems, computer-aided design tools for distributed systems, and autonomous control technology for large space systems.

- Develop technology for a disturbance-insensitive pointing mount, berthing control for precision pointing for flexible spacecraft with articulated members, multiple platform control and sensing for rendezvous and docking.

- Develop technology for large momentum control devices, combination momentum control and energy control devices, and advanced guidance and control devices.

Human Factors

Develop technology base for optimal allocation of functions to humans or to automation and for designing maximally effective, efficient and safe roles, work stations, tools and procedures for use in space operations.

- Develop human factors technology base for enhancing human ability to perform tasks (i.e., inspection, maintenance, assembly, deployment, retrieval, transfer) efficiently, effectively and safely in the extra-vehicular active environment.

- Develop technology base to enhance capability of humans to perform tasks remotely via teleoperators. Long-range goal is telepresence capability which would render remote operations as easy as hands-on operation.

- Develop design techniques for optimizing human interface with intelligent computer systems and for effective use of intelligent job aids in space-related tasks.

o Space Energy Conversion R&T

Provide the technology for the development of future space power and electric propulsion systems.

- Provide technology development for high capacity centralized thermal utility system inclusive of transport system, thermal acquisition system, and heat rejection system, technology goal for ground demonstration in FY 1986.

- Develop technology for power system automation technology for managing the distribution and power processing subsystems of large space power systems, ground demonstration in FY 1986.

- Develop high-power, high-voltage electric component technologies (transistors, capacitors, converters, rotary power transmission joints, transmission lines) for space platform applications in the late 1980's.

- Develop technology for future electric propulsion systems with application to attitude control and orbit maintenance for future large space structures. Emphasize high leverage component technologies to increase thrust-to-power and thrust-to-mass ratios.

- Develop photovoltaic energy conversion technology to reduce cost and mass and increase operating lifetimes of solar cells and blankets.

- Investigate the interaction of the space environment with high-voltage power systems.

- Develop high-energy-density, high reliability and lower cost electrochemical energy conversion and storage devices through technology advances in cell technology materials, thermal management, advanced designs, and operating techniques.

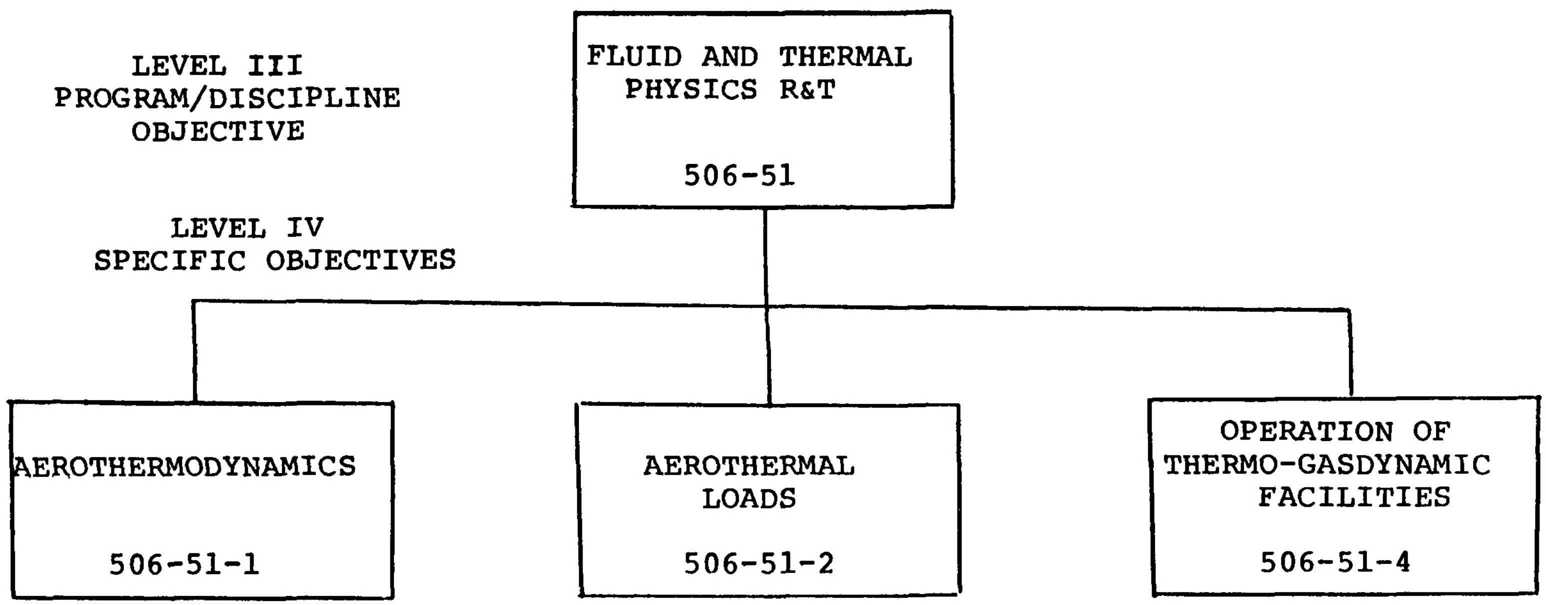
- Advance fuel cell and electrolysis technology and integrate as a regenerative fuel cell electrical power system.

PROGRAM/DISCIPLINE OBJECTIVES

FLUID AND THERMAL PHYSICS R&T

FLUID AND THERMAL PHYSICS R&T WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Fluid and Thermal Physics R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Aerospace Research Division/Clinton E. Brown

PROGRAM/DISCIPLINE OBJECTIVE:

To advance the understanding and capability to predict fundamental aerothermodynamic phenomena to permit optimization of advanced aerospace vehicles in the early stages.

SPECIFIC OBJECTIVES:

- Aerothermodynamics: To provide the experimental techniques and facilities, analytical methods, and the fundamental aerothermodynamic data base needed to permit the design of safe, economical, efficient, and reliable advanced aerospace vehicles.

- Aerothermal Loads: To provide the experimental techniques and facilities, analytical methods, and the fundamental aerothermal loads data base needed to develop the capability to predict aerothermal flow phenomena and loads for typical configurations and detailed surface geometries of existing and advanced aerospace vehicles.

- Operation of Thermo-Gasdynamic Facilities: To provide the operational and maintenance resources necessary for the ground-based gasdynamic and aerothermal test facilities to support the experimental activities required for research and technology programs in the areas of aerothermodynamics, aerodynamics and materials and structures.

SPECIFIC OBJECTIVE

TITLE: Aerothermodynamics

Program/Discipline Objective Title: Fluid & Thermal Physics R&T

Responsible Organization/Individual: Aerospace Research Division/Lana M. Couch

SPECIFIC OBJECTIVE:

To provide the experimental techniques and facilities, analytical methods, and the fundamental aerothermodynamic data base needed to permit the design of safe, efficient, economical, and reliable advanced aerospace vehicles.

- Generic:

  To improve the understanding of fundamental aerodynamic and aerothermodynamic flow phenomena in the continuum, transitional, and rarefied flow regimes.

  - Provide experimental data base and extend analytical techniques for prediction of fundamental aerodynamic and aerothermodynamic flowfield phenomena.
  - Provide computational techniques required for correlation of ground facility and flight data for fundamental aerothermodynamic and aerodynamic data, and for aerodynamic performance characteristics of advanced aerospace vehicles.
  - Improve wind-tunnel technology, test techniques, and instrumentation for fundamental aerothermodynamic research and for experimental determination of aerospace vehicle aerodynamic and aerothermodynamic performance characteristics.

- Platform:

  Provide the computational techniques needed to predict the contamination and aerodynamic performance impacts of a low-Earth-orbit space station.

  - Investigate the impact of contamination due to propulsion exhaust products from nearby vehicles and provide analyses of space station configuration aerodynamic performance and interaction with rarefied Earth atmosphere.

- o Transportation:

  Develop a technology base which will provide weight and cost reductions and improved performance in the design of existing and advanced transportation systems.

  - Provide analyses of flight data from the Space Shuttle orbiter and the orbiter experiments (OEX) with emphasis on enhancing the flight data base required to improve existing and advanced transportation system configurations.

  - Provide analyses of aerothermodynamic and aerodynamic performance characteristics of advanced earth-to-orbit and entry transportation system configurations.

  - Provide analyses of aerothermodynamic and aerodynamic performance characteristics of aeroassisted orbital transfer vehicle configurations.

TARGETS:

- o Provide surface temperature and heating rate analyses of IRIS flight data - FY 1983.

- o Develop 3-dimensional complex geometry heat transfer code for high angle of attack to include equilibrium real gas and variable edge entropy - FY 1983.

- o Establish wind-tunnel data base for development and validation of 3-dimensional viscous codes to predict complex, separated flows - FY 1983.

- o Develop Monte Carlo flowfield solutions for an aerobraking orbital transfer vehicle configuration in the transitional regime, and for control jet plume at orbital altitudes; and initiate development of Monte Carlo capability to predict space station component orbital drag - FY 1983.

- o Assess overall windward heat transfer results and anomalies from Shuttle OFT flights; and develop Flight Data Book for Shuttle OFT flights to compare to wind-tunnel Aero Data Book - FY 1983.

- o Develop numerical techniques to predict turbulent flow and heating rates for leeside surface regions of vehicles at high angle of attack - FY 1983.

- o Develop robust flow-aligned, 3-dimensional numerical technique for predicting current and future space transportation system flowfields and compare with IRIS flight data - FY 1984.

- o Develop leeside and fuselage side heat transfer prediction method from orbiter and SILTS flight data and compare SEADS-based aerodynamics to prior flight data experience and wind-tunnel Data Book - FY 1984.

- o Apply Monte Carlo techniques to improve Space Station orbital drag predictions and to assess vehicle interaction effects on control jet plume environment - FY 1984.

- o Establish a wind-tunnel data base consisting of a matrix of leading-edge radius/sweep/Reynolds number combinations to determine effects of leading-edge vortex on aerodynamics - FY 1985.

- o Provide experimental data base to validate 3-dimensional viscous codes for predicting flows over complex vehicle geometries - FY 1986.

JUSTIFICATION:

Aerothermodynamic and aerodynamic criteria provide environmental and performance requirements needed for design of future aerospace vehicles. Additional requirements, such as reusability of transportation systems and aeroassisted maneuvering of orbital transfer vehicles, have placed increased emphasis on defining and understanding the interactions between the aerothermodynamic environment and the vehicle aerothermal protection systems. Progress in these technical areas will result from the combination of NASA's unique experimental facilities and established personnel expertise in both experimental and numerical analyses of aerothermodynamic phenomena and aerodynamic performance characteristics and their significance to vehicle design. Further, flight data obtained from the orbiter and orbiter experiments provide unprecedented opportunities for validation of both ground facility data and numerical techniques applicable to the full orbiter entry environment. A more comprehensive, validated data base and the resulting improvements in prediction techniques will provide the required design inputs for less conservative optimization of future aerospace vehicles for safety, cost, durability, and performance.

SPECIFIC OBJECTIVE

TITLE: Aerothermal Loads

Program/Discipline Objective Title: Fluid & Thermal Physics R&T

Responsible Organization/Individual: Aerospace Research Division/Lana M. Couch

SPECIFIC OBJECTIVE:

o Generic:

To provide the experimental techniques and facilities, the analytical methods, and the fundamental aerothermal loads data base needed to develop the capability to predict aerothermal flow phenomena and loads for typical configurations and detailed surface geometries of existing and advanced aerospace vehicles.

o Provide experimental aerothermodynamic data base to improve the understanding of the interaction of fundamental flow phenomena for typical configurations and detailed surface geometries of aerospace vehicles.

o Develop numerical techniques for prediction of aerothermal performance characteristics of aerospace vehicles.

o Improve wind-tunnel technology, test techniques, and instrumentation for fundamental aerothermodynamic research and for experimental determination of aerospace vehicle aerothermal loads performance characteristics.

TARGETS:

o Define heating and flowfield on large blunt cone for forward and tangential injection of varying amounts of mass addition cooling - FY 1983.

o Correlate aerothermal test results with analysis for 3-dimensional flow over large, curved surface, fuselage-shaped configuration - FY 1983.

o Correlate aerothermal data with analytical results of parametric configuration study for flow over simulated, thermally-bowed (spherical) thermal protection system on flat surface - FY 1983.

o Establish wind-tunnel data base for heating and flow phenomena near cylindrical protuberances submerged in and protruding through thick boundary layers of hypersonic flow - FY 1984.

- o Define heating and flow phenomena for simulated, curved RSI thermal protection system tiles, without gap filler, mounted on a curved surface - FY 1984.
- o Provide correlation of aerothermal test results with analytical prediction for flow over large, lifting surface configuration - FY 1985.

JUSTIFICATION:

Aerospace vehicle performance can be significantly constrained through overly conservative designs driven by unknown heating and pressure effects associated with flow interference from vehicle contours, surface intersections, and surface discontinuities. Flow interference can produce critically high heating and pressure loading over a very localized area or may elevate the aerothermal loading over a large portion of the vehicle. Historically, experimental investigations of potentially critical aerothermal loads have been conducted in response to a discovered deficiency, when design alternatives are quite limited. Development of a wind-tunnel aerothermodynamic data base to improve the capability to predict both the magnitude and the extent of the aerothermal loads for the complex flow/surface interactions will permit optimization of future aerospace configurations and will minimize the need for overly conservative designs of the aerothermal protection systems.

SPECIFIC OBJECTIVE

TITLE: Operation of Thermo-Gasdynamic Facilities

Program/Discipline Objective Title: Fluid and Thermal Physics R&T

Responsible Organization/Individual: Aerospace Research Division/Lana M. Couch

SPECIFIC OBJECTIVE:

o Generic:

To provide the operational and maintenance resources necessary for the ground-based gasdynamic and aerothermal test facilities to support the experimental activities required for research and technology programs in the areas of aerothermodynamics, aerodynamics and materials and structures.

- o Support code validation and turbulence modeling for computational fluid dynamics program development.
- o Support experimental testing and evaluation of orbiter flight experiments.
- o Support experimental assessment of entry vehicle and aeroassisted vehicle concept development and enhancement.
- o Support development and testing of improved thermal protection systems.

TARGETS:

o This specific objective supports targets listed in the Fluid and Thermal Physics and Materials and Structures programs.

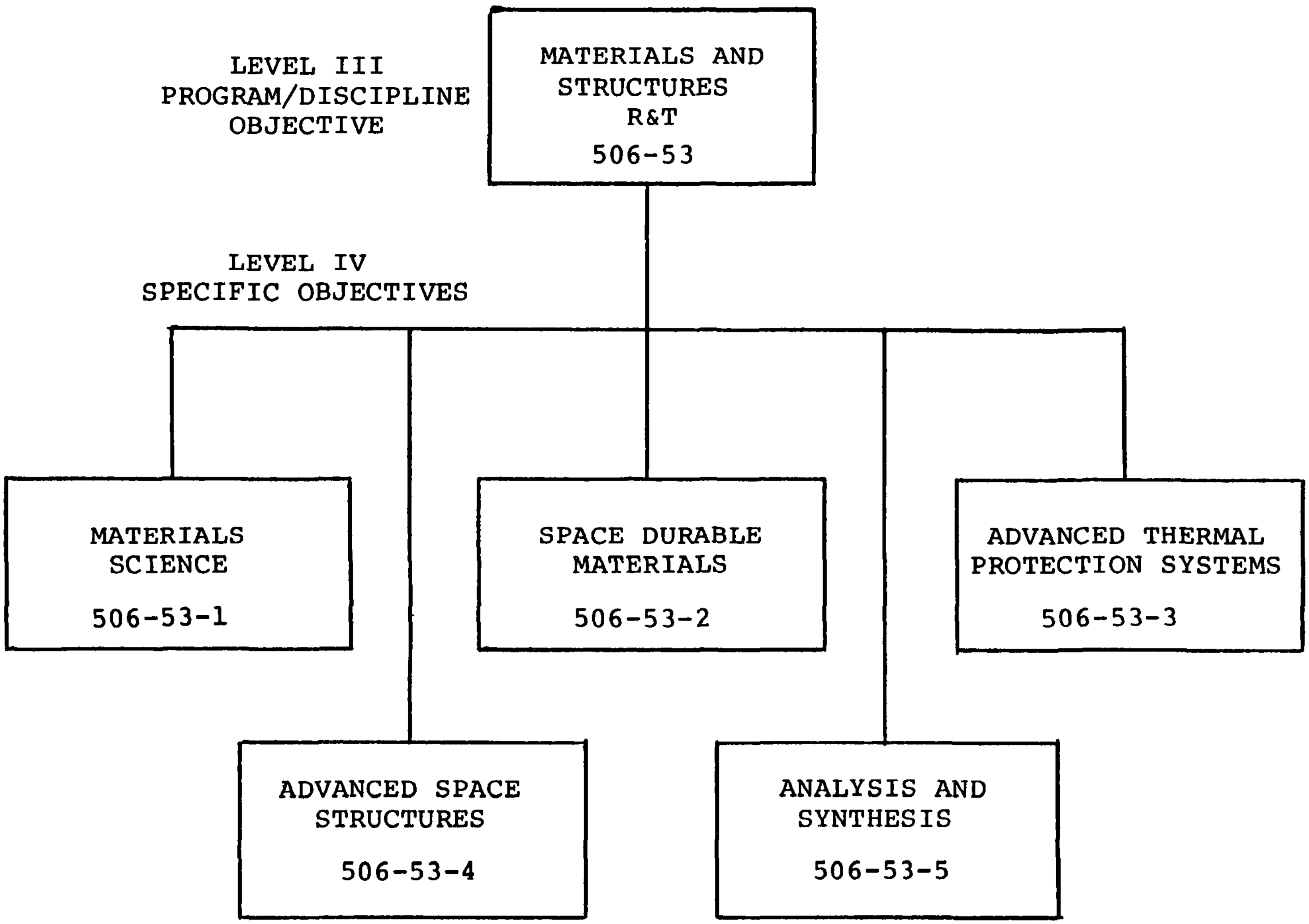
JUSTIFICATION:

The thermo-gasdynamic facilities provide support as required for research and development programs of the Thermo- and Gas-Dynamics Division, Ames Research Center; other NASA Centers; Department of Defense; other government agencies; and industry. The unique capabilities of these facilities provide experimental data which further the state of the art in thermal protection system research and in vehicle configuration research. The facilities also provide data necessary for the verification of advanced computer codes being developed to solve complex flow field problems.

MATERIALS AND STRUCTURES R&T

MATERIALS AND STRUCTURES R&T WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Materials and Structures R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Aerospace Research Division/Charles F. Bersch

PROGRAM/DISCIPLINE OBJECTIVE:

To provide advanced materials and structures technology that will allow the development of future space systems with significant improvements in performance, durability, and economy. Major emphases are given to advancing the state of the art of structural concepts and advanced materials applications for large-area space structures, spacecraft, and advanced space transportation systems.

SPECIFIC OBJECTIVES:

- Materials Science: To obtain a greater understanding of the nature of solids and their surfaces and, by such studies, develop guidelines for improving the physical and mechanical properties of structural materials.

- Space Durable Materials: To provide the technology necessary to assure the timely availability of materials for spacecraft, large-area space structures, and advanced space transportation systems. Major emphases include dimensional stability, environmental durability for at least ten years in LEO and GEO, resistance to hypervelocity impact from space debris and durable/repairable thermal control coatings.

- Advanced Thermal Protection Systems (TPS): To provide thermal protection concepts and materials for the heat shields of Earth and planetary entry vehicles and probes.

- Advanced Space Structures: To develop the structures technology required for the design of future large-area space systems, including erectable/deployable concepts, packaging, optimum member sizes and durability. To develop and validate concepts for integral cryotankage systems and evaluate structure/TPS configurations for optimum efficiency.

- Analysis and Synthesis: To develop advanced structural and thermal analysis methods for predicting the nonlinear behavior of aerospace structures under mechanical and thermal excitations. To develop mathematical algorithms for multidisciplinary optimization methods for aerospace structures. To develop and validate analysis and test methods for the prediction and verification of structural response in dynamic, acoustic, and thermal environments for use in the support of preliminary and advanced design, optimization, and qualification of space transportation systems and payloads.

SPECIFIC OBJECTIVE

TITLE: Materials Science

Program/Discipline Objective Title: Materials and Structures R&T

Responsible Organization/Individual: Aerospace Research Division/Michael Greenfield

SPECIFIC OBJECTIVE:

- Generic:

To obtain a greater understanding of the nature of solids and their surfaces and, by such studies, develop guidelines for improving the physical and mechanical properties of structural materials.

- Investigate, on an atomic scale, metal surface/environment interactions, including corrosion attack.
- Predict the properties of materials by extrapolating the calculated properties of atomic clusters.
- Determine reaction mechanisms in polymeric systems and rates of high energy radiation damage.
- Establish the fundamental mechanisms of friction, wear and adhesion, and identify methods for improved surface protection. Develop and characterize advanced lubricants and materials for bearings, seals, and gears.
- Investigate new classes of materials for high temperature application.

TARGETS:

- Identify an approach in FY 1983 to achieve ductility in the intermetallic compound Ni_3Al.
- Identify the chemical decomposition mechanisms of high-temperature experimental oils in air, including a catalytic influence of various metals present in bearings and lubrications systems, in FY 1983.

- By FY 1984, characterize the effect of several layers of hydrogen atoms on the lattice of iron, including force interactions of three atoms and the effect of other impurity atoms such as sulfur.

- Characterize, by FY 1985, the molecular origins of mechanical properties and durability in the glassy state in polymers.

- Identify and characterize, by FY 1985, primary chemical degradation mechanisms induced by the space environment and assess their effects on long-term behavior of composites.

- Develop, by FY 1985, a strength model which identifies ranges of point defect concentration and/or electron-to-atom ratios of aluminide intermetallics to improve high-temperature strength.

JUSTIFICATION:

The demands of the aerospace industry for improved performance and reliability are taxing the capabilities of materials in terms of mechanical properties at high temperature and in aggressive environments. Materials science seeks to provide the tools and the understanding of the behavior and properties of materials. Only through an understanding of materials properties, mechanisms of failure, and the interactions between materials and the chemical and mechanical environments, can new materials be synthesized, developed, or improved.

SPECIFIC OBJECTIVE

TITLE: Space Durable Materials

Program/Discipline Objective Title: Materials and Structures R&T

Responsible Organization/Individual: Aerospace Research Division/Charles F. Bersch

SPECIFIC OBJECTIVE:

To provide the technology necessary to assure the timely availability of materials for spacecraft, large-area space structures, and advanced space transportation systems. Major emphases include dimensional stability, environmental durability for at least ten years in LEO and GEO, resistance to hyper-velocity impact from space debris and durable/repairable thermal control coatings.

- Generic:

  To develop tougher, durable composite materials for improved structural efficiency and performance of space structures for advanced space systems. To determine the significant damage mechanisms due to space environmental effects and characterize and evaluate new and improved composites which are resistant to damage in this environment.

- Transportation:

  Develop and evaluate composite materials for long-life, high-temperature structural applications for advanced space transportation systems.

- Spacecraft/Platform:

  To develop materials for structural applications that are dimensionally stable for at least ten years to the space environment at LEO and GEO. Characterize and evaluate the behavior of composites to high velocity impact of earth-orbit space debris. Develop durable/repairable thermal control coatings for space structural applications.

TARGETS:

- o Determine the importance of high-temperature composites for advanced space transportation systems by the end of FY 1983.
- o Identify radiation damage mechanisms in polymeric matrix composites in a simulated space environment by FY 1984.
- o Develop preliminary methodology for accelerated testing of polymeric materials in simulated space environments by FY 1984.
- o Develop/utilize experimental and analytical methods to characterize the dimensional stability of candidate space materials by FY 1984.
- o Evaluate the resistance of composite materials to hypervelocity impact by simulated debris 1mm to 10cm in diameter by FY 1985.
- o Provide durable/maintainable thermal control coatings for large-area structures by FY 1985.

JUSTIFICATION:

For space missions envisioned for the 1990's and beyond, space structures and advanced transportation systems will have to be constructed of low-cost, long-life, temperature and radiation resistant materials. Both polymeric and metal matrix composites offer the opportunity to achieve the necessary performance goals. The history of materials development shows that it takes 10 to 15 years to bring a material concept to engineering readiness. Therefore, we must continue our strong emphasis on composite research and technology if the plans for the future are to be realized.

SPECIFIC OBJECTIVE

TITLE: Advanced Thermal Protection Systems

Program/Discipline Objective Title: Materials and Structures R&T

Responsible Organization/Individual: Aerospace Research Division/Michael A. Greenfield

SPECIFIC OBJECTIVE:

To provide thermal protection concepts and materials for the heat shields of Earth and planetary entry vehicles and probes.

- o To evaluate and improve the performance of the Shuttle thermal protection system (TPS).
- o To minimize planetary probe heat shield weights.
- o To provide minimum-weight TPS for fully reusable advanced space transportation systems.
  - o Generic:

    To develop durable and minimum weight composites for planetary heat shield applications. Demonstrate improved durability and performance of reinforced carbon-carbon composite and associated coatings in simulated reentry environments.
  - o Transportation:

    To develop ceramic, advanced carbon-carbon, and metallic thermal protection systems concepts for increased durability and reduced weight. To focus activity for blanket TPS on waterproofing and emissivity issues. To develop external tank TPS alternative concepts and assess performance and cost effectiveness. To support development of advanced OTV which will use aeroassist for recovery and maneuvering.

TARGETS:

- Increase creep design stress of superalloys in the temperature range of 1400-1800°F by 25% for 1000 hours service during FY 1983.
- Demonstrate in FY 1984 the improved durability of reinforced carbon-carbon composite and its coating in simulated reentry environments.
- Develop and verify, by wind-tunnel tests, advanced metallic TPS concepts and flexible blanket ceramic insulation to withstand 100 Earth launch and reentry cycles by the end of FY 1984.
- Assess the feasibility of film cooling and heat pipes as alternate thermal control concepts for local high-heating areas by mid-FY 1984.
- Develop, in FY 1985, flexible TPS for variable geometry aero-braking entry vehicles.
- Evaluate the performance of a toughened ceramic tile TPS by FY 1985.

JUSTIFICATION:

An enhanced national program of space exploration and utilization will be possible only if costs can be reduced considerably. Reduction in the weight and refurbishment costs of the current Shuttle and improvements in advanced space transportation systems and planetary probes are therefore required if we are to meet the agency's goals. Lighter weight metallic and advanced carbon-carbon heat shields may provide long maintenance-free thermal protection systems. More refractory surface insulations may offer weight and cost savings over current leading-edge designs. Lightweight reflecting heat shields for planetary probes could minimize mission costs and, at the same time, maximize scientific payloads. Advanced heat shield concepts will also provide a greater margin of safety for spent or aborted missions in which radioisotope thermionic generators (RTG's) are utilized.

SPECIFIC OBJECTIVE

TITLE: Advanced Space Structures

Program/Discipline Objective Title: Materials and Structures R&T

Responsible Organization/Individual: Aerospace Research Division/Deene Weidman

SPECIFIC OBJECTIVE:

To develop the structures technology required for the design of future large-area space systems, including erectable/deployable concepts, packaging, optimum member sizes and durability. To develop and validate concepts for integral cryotankage systems and evaluate structure/TPS configurations for optimum efficiency.

- Generic:

  To establish optimum methods for assembling large structures in space, investigate assembly aids and determine loads imposed on a structure during deployment or construction. Investigate structural dynamics of large space structures, damping, joint characteristics, and structure/control interactions.

- Transportation:

  Define and develop new structural concepts for advanced space transportation systems. Develop and validate structural concepts for integral cryotankage systems and advanced OTV tankage systems.

- Spacecraft:

  To develop and provide spacecraft structures technology for large space antenna systems and advanced Earth-orbital spacecraft. To develop advanced precision deployable/erectable concepts and to define and evaluate reliable mechanisms for deployment/retraction.

- Platform:

  Develop advanced structural concepts and construction technology that support a space station thrust for permanent occupancy of space. Define and develop advanced deployable/erectable structural concepts that are optimized for launch and on-orbit loads, packaging, minimum weight, reliability, and will allow modular evolutionary growth. Develop space construction methods for optimization of on-orbit structural assembly.

TARGETS:

- Establish, by the end of FY 1983, structural concepts, deployment schemes, and packaging techniques that will permit planar structures on the order of 100 to 200 meters in size to be carried into orbit in one Shuttle flight and automatically deployed.
- Establish feasibility of controllable geometry serpentine beams by FY 1984.
- Establish erectable concepts and assembly methods for structures of approximately 100m. in size by end of FY 1985.
- Develop concepts for hot ACC body flap designs and component tests by FY 1985.
- Define and provide test data of effective integral tankage structure for advanced STS by FY 1986.

JUSTIFICATION:

The Outlook for Space and many other studies of future space mission requirements have defined an overriding need for large-area space structures for space platforms, communication antennas, global resources radiometers, space power systems, radio astronomy antennas, etc. Advanced structures technology will support the development of operational systems, by providing means for better packaging and weight efficiency, improved stability and accuracy, and more accurate predictions of structural behavior. Advanced STS development will require technology advancement in new concepts for integral structural/tankage designs and efficient/durable TPS concepts.

SPECIFIC OBJECTIVE

TITLE: Analysis and Synthesis

Program/Discipline Objective Title: Materials and Structures R&T

Responsible Organization/Individual: Aerospace Research Division/Sam Venneri

SPECIFIC OBJECTIVE:

To develop advanced structural and thermal analysis methods for predicting the nonlinear behavior of aerospace structures under mechanical and thermal excitations. To develop mathematical algorithms for multidisciplinary optimization methods for aerospace structures. To develop and validate analysis and test methods for the prediction and verification of structural response in dynamic, acoustic, and thermal environments for use in the support of preliminary and advanced design, optimization, and qualification of space transportation systems and payloads.

- Transportation:

  Develop improved techniques for determining vibroacoustic and transient dynamic shuttle loads. Develop techniques for combining and evaluating acoustic, transient and random loads for STS payloads which will aid in establishment of test criteria for STS payloads. Evaluate advanced STS configurations, such as wing-tip control feasibility using structural/control optimization methods.

- Spacecraft:

  Develop analysis methods to characterize nonlinear structural dynamics and dynamic response to disturbance. Develop damping and vibration isolation techniques. Develop multidisciplinary analysis capability for structure/thermal/control optimization analyses.

- Platform:

  Develop and validate advanced analysis and synthesis methods for prediction of nonlinear structural dynamics, systems identification, integrated structures/thermal/controls analysis, and optimization techniques. Develop procedures to characterize modular structures both in ground tests as well as on-orbit. Develop active and passive damping techniques to reduce, isolate, or suppress unwanted vibration. Develop computer-aided design tools to handle the large varying complexity of evolving space station design.

TARGETS:

- Define acceptable SIP stiffness limits for densified STS tile in FY 1983.
- Evaluate, by end of FY 1983, new or improved nonlinear algorithms for dynamic analysis.
- Develop improved thermal structural finite element modeling and solution techniques applicable to large aerospace structures by end of FY 1984.
- Develop and validate methods for predicting and reducing the response of large flexible space structures by FY 1984.
- Develop and demonstrate new sizing methods for thermal applications by end of FY 1984.
- Develop techniques for combining STS acoustics, rundown, and transient dynamic loads by FY 1984.
- Develop, by FY 1985, an integrated analysis/synthesis capability which addresses the dynamic behavior of large aerospace structures under mechanical and thermal excitations, including structure/controls interactions.

JUSTIFICATION:

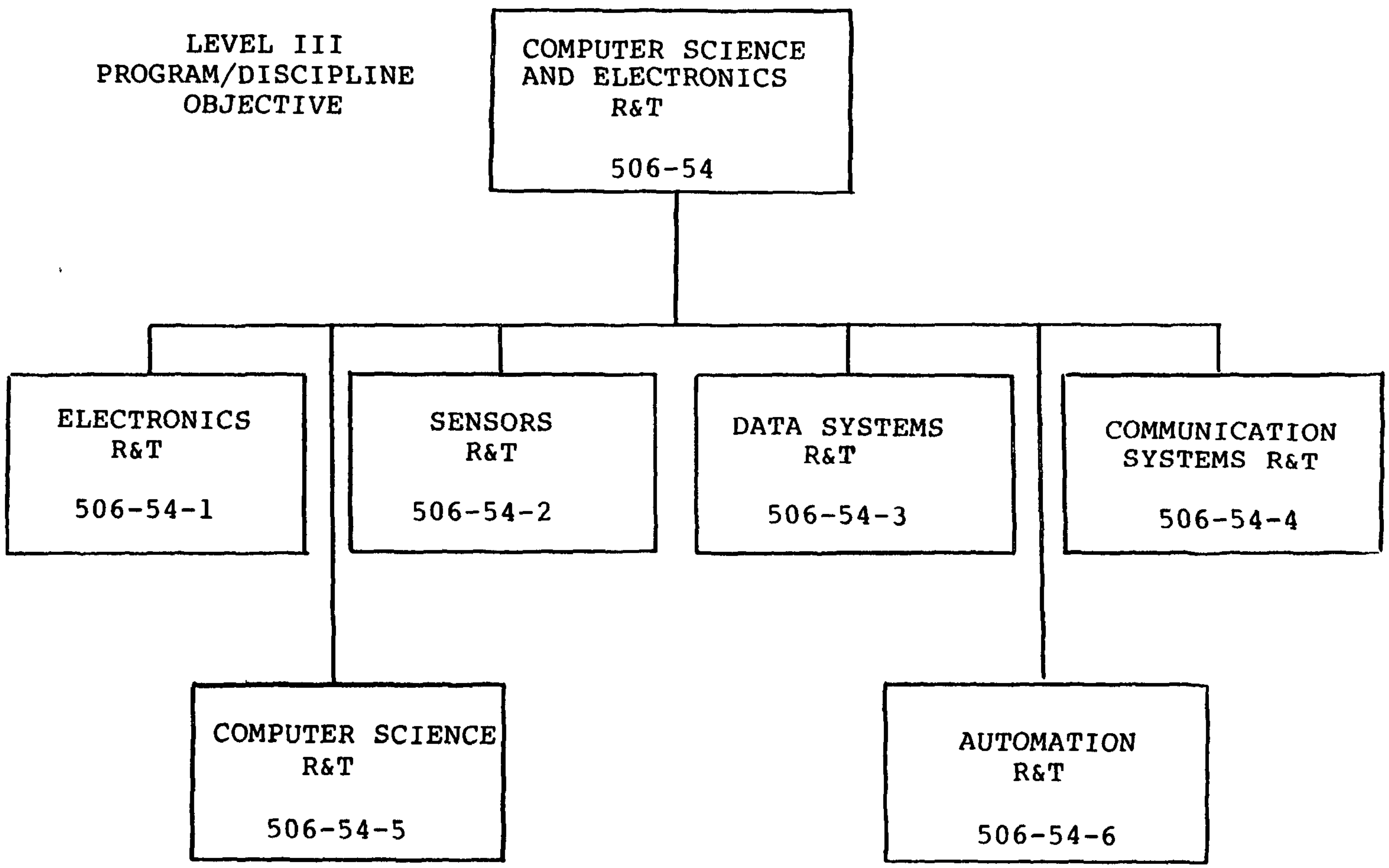
The large space structures under consideration for future space missions are flexible complex systems designed for zero-g environments, and thus not easily qualified by ground testing. Analytical

methods will have to be relied upon heavily for demonstrating their flightworthiness. For this purpose, current methods must be improved in accuracy, efficiency (cost effectiveness), and capabilities to handle the expected nonlinearities and thermal loads, and to predict dynamic collapse and other performance-limiting behavior.

Structural dynamics issues are among the major and often critical considerations which must be addressed in a space vehicle development activity in order to insure mission success. They include environmental specification, structural dynamic loads and response prediction, structural design and optimization, and structural qualification testing. For space transportation systems, aerothermal loads are also required for safe and efficient design.

COMPUTER SCIENCE AND ELECTRONICS R&T

COMPUTER SCIENCE AND ELECTRONICS R&T WORK BREAKDOWN STRUCTURE
LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Computer Science and Electronics R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Aerospace Research Division/Lee B. Holcomb

PROGRAM/DISCIPLINE OBJECTIVE:

To provide the fundamental electronics and computer science and technology base to advance theory and provide electronic device, detector, automation, computational and software technologies needed to enable future space systems; to provide the techniques and technologies required for the acquisition, processing, reduction, and distribution of space-acquired data on a real-time basis for experimental, scientific and operational space vehicles and station in the 1990-2000 time frame; and to provide the advanced high-risk microwave and optical communications technology to support the future needs of NASA, other government agencies and the private sector, and to insure the continued U.S. preeminence in satellite communications.

SPECIFIC OBJECTIVES:

- Electronics Research and Technology: To investigate and advance new and existing scientific concepts and phenomenology necessary for the development of electromagnetic devices, materials, and sources required to enable NASA thrusts and missions. To discover, develop, and evaluate new electronic and optical concepts for improved sensor capability, higher information and data transfer and storage, and real-time signal processing and controlling. To explore new and novel concepts for the implementation of advanced solid-state technology for application in the unique space environment.

- Sensors Research and Technology: To investigate, design, develop and test innovative experimental systems that exploit the unique properties of lasers and the capabilities of microwave tubes for the passive and/or active remote sensing of terrestrial, planetary, and galactic environments. To investigate, develop and test infrared detector technology to enable future NASA scientific and applications missions. To conduct research and development in the area of low and ultra-low temperature refrigerator concepts for sensor and instrumentation cooling in space.

- Data Systems Research and Technology: Develop and demonstrate the systems technology and techniques which can enable more efficient and effective transfer of useful data from the sensor to the user, and facilitate the control of sensors by a distributed body of users at substantially reduced cost and complexity, with emphasis directed toward the requirements of manned space station missions such as fault tolerance and subsystem autonomy.

- Communication Systems Research and Technology: To develop microwave and optical communication system component technology to support the space-to-space, space-to-earth data distribution/transfer requirements of NASA's future mission payloads, deep space missions and space stations; and to insure the continued U.S. preeminence in satellite communications.

- Computer Science Research and Technology: To provide an agency foundation in fundamental computer science through research and experimentation, and to facilitate the infusion of state-of-the-art computer science and technology into aerospace applications. To provide the theoretical and technology bases needed to develop advanced aerospace computing concepts and to evolve advanced system architectures in response to unique aerospace requirements. To improve the development process and the quality of aerospace-related systems and software. To provide advanced theory, concepts, techniques, and capabilities for the effective use and management of aerospace information. To provide state-of-the-art computational facilities for the conduct of research in computer science and technology for aerospace applications.

- Automation Research and Technology: To provide NASA with the basic technology required in automated planning, decision-making and problem-solving, knowledge-based systems, machine perception and machine learning to expand the applications of computer-based automation in the space program.

  To provide automated manipulation, mobility, sensing and actuation technology needed for future NASA teleoperation and robotics applications such as satellite servicing, space assembly, and space construction.

SPECIFIC OBJECTIVE

TITLE: Electronics Research and Technology

Program/Discipline Objective Title: Computer Science and Electronics R&T

Responsible Organization/Individual: Aerospace Research Division/Martin M. Sokoloski

SPECIFIC OBJECTIVE:

To investigate and advance new and existing scientific concepts and phenomenology necessary for the development of electromagnetic devices, materials, and sources required to enable NASA thrusts and missions. To discover, develop, and evaluate new electronic and optical concepts for improved sensor capability, higher information and data transfer and storage, and real-time signal processing and controlling. To explore new and novel concepts for the implementation of advanced solid-state technology for application in the unique space environment.

- Generic:

  To develop and explore new lasing media and methods from the ultraviolet (UV) to the submillimeter portion of the electromagnetic spectrum to develop and explore new and novel concepts in solid-state technology that will lead to innovative devices and components for application in the unique space environment, and to discover, evaluate, and develop new and innovative concepts for optical processors that can be used to manipulate large streams of data and provide solutions to control equations in real time.

- Spacecraft:

  To explore physical mechanisms for the space radiation degradation of electronic components and devices; to develop and evaluate fabrication concepts to alleviate radiation degradation in components and devices; and to investigate novel methods to reduce the sensing data burden on spacecraft communications and on ground-based processing facilities.

TARGETS:

- Determine if CdS will be a useful lasing medium by employing it in a laser cavity - FY 1983

- o Design, develop, and test submillimeter wave sensing systems using laser local oscillator sources for atmospheric and astronomical observations - FY 1983
- o Develop nonintrusive techniques to measure the temperature of a gas in a wind tunnel - FY 1983
- o Complete proof of principle of Si-SiGe superlattice - FY 1983
- o Complete proof of principle and demonstrate feasibility of self-structured current access magnetic bubble memory - FY 1983
- o Develop integrated optical Bragg receiver - FY 1983
- o Determine the nature of space-radiation effects in silicon base MOSFET technology and how to rectify the effects in the fabrication process - FY 1983
- o Measure, quantify, and qualify the radiation from the submillimeter wave diffraction radiation generator - FY 1984
- o Complete proof of principle of 600-1000 GHz submillimeter wave tube oscillator - FY 1986

JUSTIFICATION:

The pervasive nature of coherent sources and devices such as lasers and micro- and submillimeter electron tubes manifests itself in a multitude of space applications. Some of these include communications, fiber optic data transmission, optical signal processors, integrated optical devices for scene correlations, pattern recognition, and real-time processing of synthetic aperature radar signals and passive and active remote sensing. These applications are threaded through a host of agency missions from large space structures and observations of terrestrial, planetary, and galactic phenomena, to laser diagnostics for wind tunnel measures. A benchmark area is solid-state research for the exploration and utilization of new materials, devices and components for ultimate utilization in advanced mission areas. There is a need to understand and model the basic failure mechanisms associated with the unique space environment on very large-scale integrated circuits. With this fundamental understanding, methods can be devised which will enable a reliability assessment of a given process and provide the necessary information to eliminate the failure or undesirable degradation.

SPECIFIC OBJECTIVE

TITLE: Sensors Research and Technology

Program/Discipline Objective Title: Computer Science and Electronics R&T

Responsible Organization/Individual: Aerospace Research Division/Martin M. Sokoloski

SPECIFIC OBJECTIVE:

To investigate, design, develop, and test innovative experimental systems that exploit the unique properties of lasers and the capabilities of microwave tubes for the passive and/or active remote sensing of terrestrial, planetary, and galactic environments. To investigate, develop and test infrared detectors technology to enable future NASA scientific and applications missions. To conduct research and development in the area of low and ultra-low temperature refrigerator concepts for sensor and instrumentation cooling in space.

o Spacecraft:

To investigate, develop, and test advanced concepts that exploit the unique properties of coherent sources, such as lasers and microwave tubes, to fulfill NASA's mission in terrestrial, planetary, and astronomical sensing; to investigate, develop, and evaluate sensing and detecting components and devices in order to enable new scientific application mission capabilities through improved bandwidth, better spectral and spatial resolution, and greater sensitivity; and to conduct research and advanced technology in the area of low and ultra-low temperature refrigeration systems for the cooling of sensors, instruments, electronic components, and experiments in space.

TARGETS:

o Develop and test high-resolution SAR antenna systems and associated RF technology applicable to all-weather earth and ocean sensing with capabilities of wide swath width, selectable frequency and selectable polarization operation - FY 1983

o Design, develop, and evaluate advanced systems and technology concepts for active and passive microwave sensing of the Earth in selected bands in the wavelength region from 0.6 - 22.4 GHz - FY 1983

- o Design, fabricate, and evaluate high-resolution microwave imaging systems. Concepts to be addressed shall include pushbroom arrays of breadboard microwave precision radiometers and very large antennas using multiple beams and mechanical scan techniques - FY 1983

- o Design, develop and test infrared image sensors using hybrid area arrays that operate in both the short-wave infrared (SWIR) and long-wave infrared (LWIR) spectral regions - FY 1983

- o Design, develop, test and evaluate, using ground-based telescopes, far-infrared sensor systems using extrinsic or intrinsic and monolithic or hybrid devices for the wavelength region 2 to 120 micrometers - FY 1983

- o Develop and test infrared image sensors utilizing 1000-element linear hybrid focal plane arrays (8-12 μm) for thermal imaging of planetary and terrestrial scenes - FY 1983

- o Develop and test infrared image sensors utilizing linear and area monolithic focal planes which operate both in the SWIR and LWIR spectral regions - FY 1983

- o Develop and test tunable CO_2 laser systems which operate in both the pulsed and continuous wave (CW) mode for detecting trace atmospheric constituents, pressure, temperature, and wind velocities - FY 1983

- o Develop heterodyne spectroscopy system for astronomical measurements out to 20 μ in wavelength - FY 1983

- o Complete testing of technology model for candidate long-lifetime mechanical cooler - FY 1983

- o Complete test of thermal model of the advanced radiator under simulated space conditions - FY 1983

- o Complete tests of critical components for long-lifetime (at least three years) liquid-helium coolers - FY 1983

- o Complete tests of adsorption and magnetic cooler stages for long-lifetime coolers (at least five years) - FY 1983

- o Develop and test laser ultraviolet fluorescence sensor systems using excimer lasers for studies of planetary atmospheres - FY 1983

- o Develop and flight test a tunable laser heterodyne spectrometer for the measurement of atmospheric species - FY 1983
- o Complete demonstration of $Helium^{-3}$ cooler to cool sensor in zero-g to 0.3K - FY 1984
- o Demonstrate mode-stabilized AlGaAs semiconductor lasers with long lifetimes, different wavelength devices, and 40 dB isolation between modes for use in optical disk recorder and data processing systems - FY 1985

JUSTIFICATION:

This program involves the development and test of infrared sensor systems which will satisfy the requirements of future NASA planetary, terrestrial, and astrophysical missions where there are needs for information related to thermal imaging, atmospheric and surface composition, stellar mapping, and spectroscopy. Terrestrial and planetary remote-sensing systems utilize the region from 1 to 15 micrometers, and astronomical interests include the region from 2 to 1000 micrometers. The sensors will utilize extrinsic and intrinsic semiconductor materials and will be monolithic or hybrid, depending on the unique sensor requirements. Time delay and integration, geometric and radiometric calibration, and other pre-processing functions that are amenable to inclusion on the focal plane will be made part of the system in order to obtain the required system performance.

This program also relates primarily to sensor systems that exploit the unique properties of laser sources. By selection of the appropriate wavelength, it becomes possible to detect atmospheric water vapor and trace chemical species. By use of range-gating techniques the vertical or horizontal distribution of these parameters can also be determined. Laser sensors can also be used to determine cloud structure, distribution, wind velocity, surface pressure, and temperature. Short-pulse, high-energy lasers may be used to make geodetic measurements and measurement of crustal motions in the centimeter range. The ability to tune the lasers increases their versatility.

Increasing numbers of NASA payloads will require cryogenic cooling. Mission types include Earth applications, imaging of cold planets, gamma-ray astronomy, infrared astronomy, gravity wave detection, relativity, basic research requiring low temperatures, and payloads utilizing superconducting devices. Improved cryogenic systems are required to provide for the wide range of needs imposed by these missions. Parameters of particular importance for the cryogenic cooling systems are cooling capacity, lifetime, and required operating temperature and temperature stability.

Superconducting components (e.g., computer elements, motors, bearings) offer the potential for enhanced performance for advanced space systems. It is expected that superconducting devices will be increasingly used in the 1980-1990 time period.

SPECIFIC OBJECTIVE

TITLE: Data Systems Research and Technology

Program/Discipline Objective Title: Computer Science and Electronics R&T

Responsible Organization/Individual: Aerospace Research Division/C. Fuechsel

SPECIFIC OBJECTIVE:

Develop and demonstrate the systems technology and techniques which can enable more efficient and effective transfer of useful data from the sensor to the user, and facilitate the control of sensors by a distributed body of users at substantially reduced cost and complexity, with emphasis directed toward the requirements of manned space station missions such as fault tolerance and subsystem autonomy.

- Generic:

  Extend the theoretical basis for modeling and translating data structures between heterogeneous data bases. Develop architectures for efficient access to very large data bases of space sensor information. Demonstrate remote access to a large on-line data base of space sensor information.

- Transportation:

  Enable more reliable and cost effective data storage devices to be employed in operational Space Transportation System avionics.

- Spacecraft:

  Develop technology to enable very high speed processing of onboard sensor data and rapid processing of great volumes of space sensor data by ground-based facilities. Reduce the cost of processing and storing space information by several orders of magnitude, while increasing the lifetime of storage media.

o Platform:

Develop advanced data system architectures which are readily adaptable in flight to changing mission requirements and which provide automatic detection and recovery from component failure in flight. Provide relative insensitivity to evolving device technologies and localize the effects of changes within subsystems to reduce the cost and complexity of system-level integration testing and verification. Demonstrate technology to facilitate the planning and control of sensor observations by a large and geographically distributed body of investigators and data users associated with a complement of sensors aboard space station.

TARGETS:

- o Develop a parallel data processor capable of effective sequential execution rates in excess of one billion fixed-point operations per second by FY 1983.
- o Develop interface standards and protocols applicable to advanced space data systems by FY 1983.
- o Develop tools and techniques to improve the management and coordination of technical research and development programs by FY 1983.
- o Complete development of the information adaptive on-board radiometric and geometric correction demonstration by FY 1983.
- o Develop a ground data base management system to demonstrate high-rate data ingest, automatic cataloging, and concurrent access by remote users to a large body of on-line space information by FY 1984.
- o Develop an optical disk recorder capable of ingesting and retrieving data at 50 million bits per second, and storing 10^{11} bits per disk by FY 1984.
- o Assess the feasibility of developing a flight optical disk data storage subsystem and develop requirements and a program plan to accomplish a demonstration by FY 1984.

- o Continue development (with U. S. Air Force) of high-density, wide temperature range magnetic bubble memory devices using ion implant technology by FY 1984.

- o Develop models for data systems configurations expected to be developed in the 1990's, by FY 1984.

- o Demonstrate mission planning graphics aids in combination with communications services to enable collaborative planning and control sessions among a geographically diverse team of investigators by FY 1984.

- o Develop concepts and system architectures for affordable high-performance-deep space data systems by FY 1985.

- o Develop a pilot demonstration of technology to provide direct transmission of flight science data to teams of scientific investigators by FY 1985.

- o Develop techniques for implementing autonomous onboard data management systems which exhibit very high degrees of adaptability to changing mission requirements, and automatic detection and recovery in the event of component failures by FY 1985.

- o Develop very high-speed integrated circuit technology in the context of specialized onboard data processing applications by FY 1985.

- o Develop a high-speed optical data bus system and components suitable for space flight by FY 1985.

- o Develop high-speed Gallium-Arsenide data handling electronic technology demonstration suitable for space flight by FY 1985.

- o Develop a prototype magnetic bubble memory system to demonstrate technology readiness in the form of a functional replacement for the Space Transportation System (STS) electro-mechanical mass memory unit by FY 1985.

- o Develop a special purpose pipeline processing architecture capable of producing synthetic aperture radar images at the real-time sensor rate by FY 1986.

JUSTIFICATION:

NASA's data management system is expected to rapidly approach saturation as the Shuttle becomes operational. In an environment of ever increasing rate of generation of space data combined with the necessity to keep missions affordable, productive, and responsive to users, it is imperative for NASA to reduce the cost of information and to vastly improve the performance of systems which make such information available to users. The Data Systems Research and Technology program maintains a future oriented and macroscopic perspective of the entire information gathering process from onboard sensing and processing to the delivery of information products to their ultimate users and the inverse mission control process. From this perspective, key technology development objectives are identified which will enable the achievement of cost and performance requirements of NASA's future space information systems.

SPECIFIC OBJECTIVE

TITLE: Communication Systems Research and Technology

Program/Discipline Objective Title: Computer Science and Electronics R&T

Responsible Organization/Individual: Aerospace Research Division/D. Santarpia

SPECIFIC OBJECTIVE:

To develop microwave and optical communication system component technology to support the space-to-space, space-to-earth data distribution/transfer requirements of NASA's future mission payloads, deep space missions and space stations; and to insure the continued U.S. preeminence in satellite communications.

- Generic:

  To provide a technology base for the development of high-efficiency, high-power microwave amplifiers for space applications in the frequency band from 1 to 200 GHz.

- Spacecraft:

  To develop microwave solid-state components for long-life, deep-space missions; millimeter/optical high-data-rate intersatellite link component technology; feed systems for multibeam antennas; and advanced generic solid-state materials and components for receivers, transmitter array antennas and signal processing systems.

- Platform:

  To develop the technology required to enable multiple simultaneous communication links including space-to-earth, intersatellite, intrasatellite and proximity links.

TARGETS:

- Develop 4.5db Noise Figure Ka-band Microwave Integrated Circuit FET Receiver - FY 1983.
- Evaluate and Demonstrate 10/22-watt X-Band Solid-State Power Amplifier - FY 1983.
- Complete Advanced Breadboard MIC EM 60 GHz Low-Noise Receiver - FY 1984.

- o Apply Pyrolytic Graphite Multistage Depressed Collector Technology to 20 GHz TWT - FY 1984.
- o Complete Preliminary Analysis of Large Antenna Flight Experiment Feed Performance - FY 1984
- o Test Prototype LMSS Multibeam Antenna Feed Integrated with Beam Forming Network - FY 1984.
- o Evaluate and Demonstrate 20/40 watt X-Band Solid-State Power Amplifier - FY 1984.
- o Develop 3.5db Noise Figure Ka-band Microwave Integrated Circuit FET Receiver - FY 1985.
- o Develop a 20 GHz GaAs Monolithic Transmit Module - FY 1985.
- o Develop a 30 GHz, GaAs Monolithic Receive Module - FY 1986.
- o Develop 20 GHz Power GaAs FET Devices with Optimal Gain, Efficiency and Bandwidth - FY 1986.
- o Demonstrate Monolithic Array Fed Reflector Antennas for Transmit and Receive Multiple Spot Beam and Scanning Beams - FY 1986 and 1987.

JUSTIFICATION:

Future NASA missions such as the Tracking and Data Acquisition System (TDAS), Space Station and Advanced Communications Satellite (ACS), in addition to planned planetary missions, will require the simultaneous multichannel transmission and distribution of data over space-to-earth, intersatellite and intrasatellite links on a near or real time basis. These programs will require long life and highly reliable communication links. Anticipated performance requirements exceed current capabilities in the component area and in available bandwidth. It is necessary, therefore, to develop the communications technology to meet unique future mission needs and to provide the technology for assessing new frequency bands.

SPECIFIC OBJECTIVE

TITLE: Computer Science Research and Technology

Program/Discipline Objective Title: Computer Science and Electronics R&T

Responsible Organization/Individual: Aerospace Research Division/R. Larsen

SPECIFIC OBJECTIVE:

To provide an agency foundation in fundamental computer science through research and experimentation, and to facilitate the infusion of state-of-the-art computer science and technology into aerospace applications. To provide the theoretical and technology base needed to develop advanced aerospace computing concepts and to evolve advanced system architectures in response to unique aerospace requirements. To improve the development process and the quality of aerospace-related systems and software. To provide advanced theory, concepts, techniques, and capabilities for the effective use and management of aerospace information. To provide state-of-the-art computational facilities for the conduct of research in computer science and technology for aerospace applications.

- Generic:

  To develop an understanding of the relationship and tradeoffs between algorithms and computer architectures for aerospace applications, and to apply this fundamental insight to the development of advanced computational concepts and optimal system architectures for this class of problems.

  To provide the theoretical and technology base for the development of aerospace-related software and information management systems. To provide the programming languages and techniques, software engineering methodologies and operating system concepts required for aerospace applications. To understand the fundamental models and principles underlying information management and provide the capability to manage scientific and engineering information.

- To investigate the theoretical basis underlying high reliability and fault tolerance of systems in order to provide insight into promising new architectural concepts. To provide the analyses required to understand the interplay between advanced architectural concepts and algorithm performance properties, including algorithmic complexity, time/space tradeoffs, convergence properties, and accuracy. To provide improved tools and techniques for analyzing and evaluating systems behavior and performance, including analytic techniques, as well as simulation and modeling.

TARGETS:

- Publish state-of-the-art assessment of concurrent processing theory and technology, including but not limited to SIMD, MIMD, data flow, associative processors, and systolic array architectures, and considering the impact and role of VLSI and VHSIC technology - FY 1983
- Complete a comprehensive 10-year plan for NASA research and technology transfer on concurrent processing - FY 1983
- Establish a capability in conceptual, analytical and simulation modeling of concurrent processes and systems - FY 1983
- Publish a state-of-the-art survey and assessment of highly reliable system theory and technology - FY 1983
- Complete a comprehensive 10-year plan for NASA research and technology transfer on highly reliable systems - FY 1983
- Establish a capability for systems research focusing on the development of highly reliable systems - FY 1983
- Develop a technical base for the representation of system design information supporting presentation from many different viewpoints - FY 1983
- Establish a capability for conducting fundamental research in algorithm analysis, complexity measures, and formal logic - FY 1983
- Establish a university-based center of excellence of computer science research for aerospace applications - FY 1983

- Establish a capability for conducting research focusing fundamental issues underlying effective large-scale scientific and engineering information management - FY 1983

- Provide computer science researchers at the NASA Centers with access to state-of-the-art computational facilities - FY 1984

- Demonstrate modular fault-tolerant spacecraft computer architecture capable of automatic reconfiguration and recovery from permanent and and transient faults - FY 1984

- Develop concurrent processing software techniques and programming languages for the Massively Parallel Processor - FY 1984

- Develop a pilot-integrated software design and management environment to evaluate techniques for automating elements of the software systems engineering process by combining technical tools with management tools and a data base management system - FY 1985

JUSTIFICATION:

Despite the incredible rate of technology advancement in the computing industry, NASA's computationally intensive applications such as image processing continue to levy computational demands which surpass state-of-the-art capability. NASA's requirements for highly reliable systems for flight applications similarly go beyond contemporary technology.

The objectives of high performance and high reliability demand innovative architectural concepts in which multiple computational processes proceed concurrently, with varying levels of coupling between the processes, as the application demands. The uniqueness and pervasiveness of NASA's requirements for concurrent processing systems demand a strong technical base within the agency to conceive, design, analyze, and ultimately implement innovative system architectures for aerospace-related applications.

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In many ways, NASA is an information-intensive organization. Much of its mission is to collect organize, and reduce data into usable scientific information. Computing is essential to achieving its objectives, evidenced by the annual expenditure of nearly a quarter of its total budget for computing and computing-related services. Given the magnitude of its continuing investment, it is essential that the agency have the technical base to utilize this technology wisely and fully. Active research and vigorous technology infusion must be conducted to maximize NASA's return on its annual investments and to assure the development of computing systems which efficiently and effectively meet NASA's needs and the needs of the aerospace scientific and industrial community.

SPECIFIC OBJECTIVE

TITLE: Automation Research and Technology

Program/Discipline Objective Title: Computer Science and Electronics R&T

Responsible Organization/Individual: Aerospace Research Division/R. Larsen

SPECIFIC OBJECTIVE:

To provide NASA with the basic technology required in automated planning, decision-making and problem-solving, knowledge-based systems, machine perception and machine learning to expand the applications of computer-based automation in the space program.

To provide automated manipulation, mobility, sensing and actuation technology needed for future NASA teleoperation and robotics applications such as satellite servicing, space assembly, and space construction.

- Generic:

  To derive new approaches, algorithms, and techniques to expand the potential for automation of space-related activities and enable autonomous operations in space.

- Transportation:

  Develop methodology and architecture for advancing and applying automation technology to current and future space transportation systems — the primary goal being to improve overall mission efficiency with attendant reductions in life cycle costs. In this activity, technology development should focus on automating mission planning, scheduling, and control functions and on vehicle subsystem management to include incipient failure detection, isolation, and repair.

  - Enhance fault detection, isolation, and recovery (FDIR) technology at the line replaceable unit (LRU) level for current and advanced space transportation systems.

- Spacecraft:

  Provide technology for improving the functionality and cost effectiveness of spacecraft systems and operations, leading ultimately to spacecraft autonomy, through the development and application of artificial intelligence and related techniques.

  - Improve the performance of the command and control process while reducing labor-intensive costs by developing automated command generation capabilities, and modeling and demonstrating command and control system designs with onboard functional command capability.

- Platform:

  Develop the fundamental technology for full sensory feedback (including visual and tactile) integrated with machine intelligence for fully automatic operation of multi-arm manipulator systems.

  Develop methodology and simulation capability and demonstrate algorithms for direct control, supervisory control, autonomous control and local intelligence in teleoperator and robotic systems.

  Develop the technology base for an experimental telepresence system which outperforms direct human manipulation.

  Develop basic expert system technology capability and identify utilization for space station and operations.

TARGETS:

- Develop and refine fundamental hypothesis formation and testing techniques in FY 1983.
- Demonstrate prototype operational planner utilizing a Voyager knowledge base to support the Uranus encounter in FY 1983.
- Demonstrate fundamental hypothesis formation and testing techniques for remote spacecraft fault detection, isolation, and recovery applications in FY 1983.

- o Provide state-of-the-art assessment of fault detection, isolation, and recovery (FDIR) technology recommending most effective directions for further research in FY 1983.
- o Develop the methodology to determine the appropriate proportions of direct control, supervisory control, and autonomous control for automated systems as a function of automation technology sophistication in FY 1983.
- o Develop and demonstrate adaptive control algorithms for end point control of two-member limber manipulators which are robust with respect to large, sudden changes in mass by FY 1984.
- o Demonstrate feasibility of knowledge-based approach for automating major FDIR functions by FY 1984.
- o Develop the fundamental technology needed for machine vision systems with target body tracking over a noisy background by FY 1984.
- o Develop and demonstrate algorithms for multi-arm manipulator coordination by FY 1984.
- o Develop expert system technology capability and validate in a NASA context by FY 1984.
- o Demonstrate automatic problem-solving of a flight operations anomaly involving multiple components or data bus failures by FY 1984.
- o Develop and demonstrate artificial intelligence techniques for information extraction from image data by FY 1985.
- o Develop tools and techniques for automating elements of the spacecraft command and control process by FY 1985.
- o Demonstrate feasibility of improving mission operations productivity and effectiveness by application of expert systems technology by FY 1985.
- o Develop tools and techniques for automating elements of the spacecraft command and control process by FY 1985.

- o Develop the technology base for an experimental telepresence system for space manipulation tasks which outperforms direct human manipulation by FY FY 1986.

JUSTIFICATION:

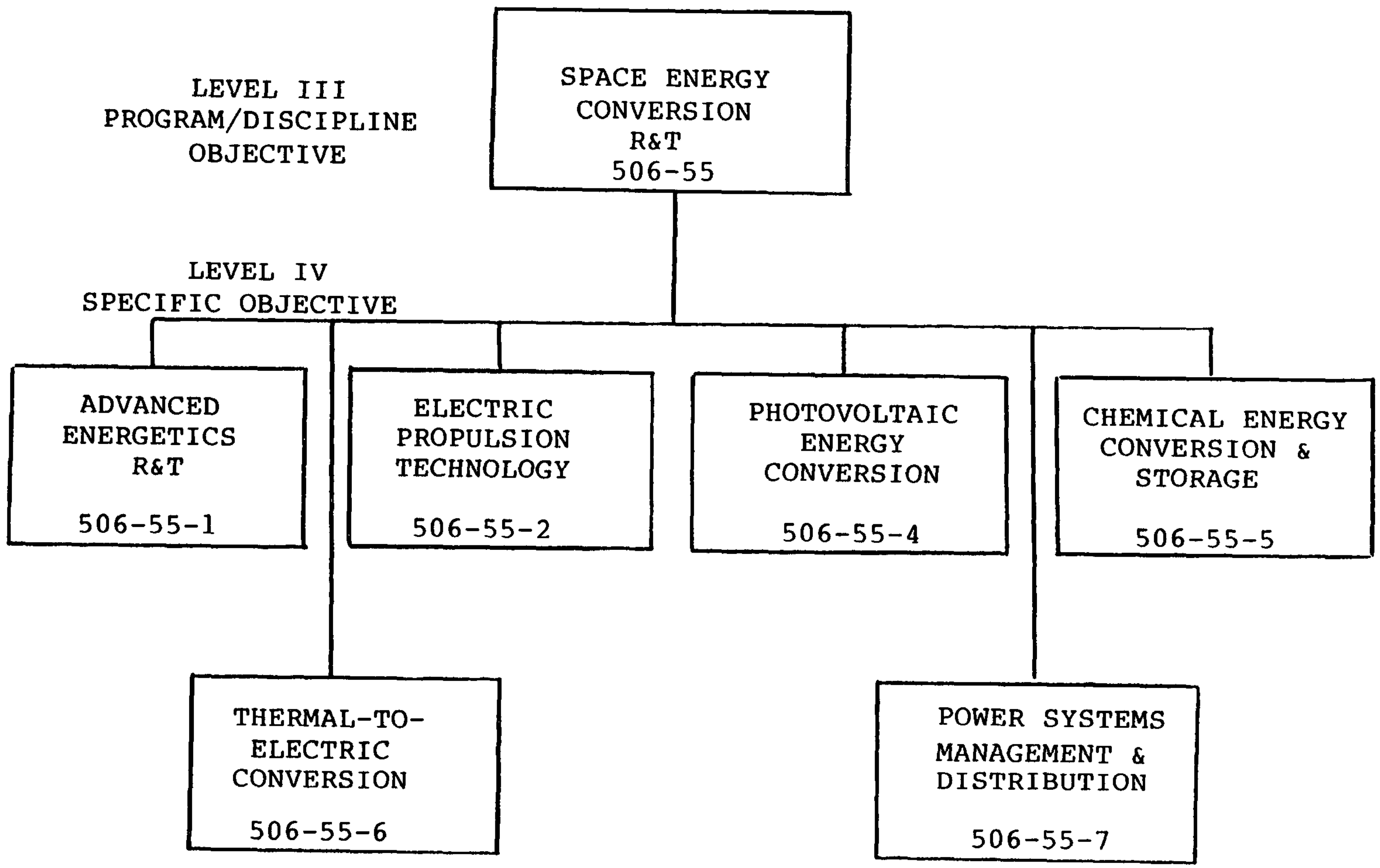
As the scope and complexity of NASA missions increase, the cost of carrying them out with conventional technology is rapidly becoming unaffordable. This becomes particularly evident when large space systems are considered.

Machine systems capable of performing remote manipulative functions, such as satellite servicing and space construction, and intelligent functions, such as scene analysis, planning, decision-making and adaptive control, can substantially enhance our ability to increase the degree of autonomy of space operations, thereby reducing mission costs and providing new mission capabilities not otherwise attainable.

7

SPACE ENERGY CONVERSION R&T

SPACE ENERGY CONVERSION R&T WORK BREAKDOWN STRUCTURE
LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Space Energy Conversion R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Aerospace Research Division/J. Mullin

PROGRAM/DISCIPLINE OBJECTIVE:

To provide the technology basis for future space power and electric propulsion systems.

SPECIFIC OBJECTIVES:

- Advanced Energetics R&T: To assess advanced concepts for space energy generation, conversion, storage, and distribution, and to develop the key technologies required to determine their feasibility.

- Electric Propulsion Technology: To develop the technology for future electric propulsion systems including thrusters and associated power processors for application to Earth Orbital and planetary missions.

- Photovoltaic Energy Conversion: To improve conversion efficiency, reduce mass, reduce cost, and increase operating life of photovoltaic converters and arrays.

- Chemical Energy Conversion and Storage: To develop critical technologies in electrochemistry which will lead to advanced primary and secondary battery and fuel cell systems.

- Thermal-to-Electric Conversion: To provide thermal conversion technology, which can be used with either nuclear or solar energy sources, that is cost and mass competitive with solar arrays or is required in applications for which alternatives are impractical.

- Power Systems Management and Distribution: To provide the technology base necessary to control the generation and distribution of energy in future space systems, and to assure their environmental compatibility.

SPECIFIC OBJECTIVE

TITLE: Advanced Energetics R&T

Program/Discipline Objective Title: Space Energy Conversion R&T

Responsible Organization/Individual: Aerospace Research Division/D. Flood

SPECIFIC OBJECTIVE:

To assess advanced concepts for space energy generation, conversion, storage and distribution, and to develop the key technologies required to determine their feasibility.

- Generic:

  Assess the technology status and potential applicability of known and proposed advanced energetics concepts and demonstrate feasibility of selected technologies.

  Investigate direct conversion of fission and solar energy into laser radiation.

  Generate and investigate novel means to convert solar and laser radiation efficiently to electricity or other useful forms of energy.

TARGETS:

- Restructure advanced concepts program in FY 1983
- Establish feasibility of the alkaline metal thermoelectric converter (AMTEC) concept in FY 1983.
- Establish feasibility of the plasma heat pipe concept in FY 1983.
- Complete H_2 absorption of CO_2 laser radiation experiment in FY 1983.
- Establish feasibility of a photoelectrolysis fuel cell recharger by end of FY 1984.

- o Demonstrate closed-cycle, solar-pumped laser by the end of FY 1984.
- o Determine feasibility of the optical rectifier laser receiver by mid-FY 1985.
- o Establish feasibility of laser driven MHD in FY 1985.
- o Demonstrate feasibility of solar driven MHD by end of FY 1986.
- o Demonstrate 100W solar-pumped laser in FY 1986.
- o Decide on laser receiver technology for demonstration in FY 1987.
- o Establish feasibility of non-Carnot limited conversion methods by end of FY 1987.
- o Decide on laser technology in FY 1988.

JUSTIFICATION:

Advanced energetics research is in direct support of power technology of the future and provides the basic efforts needed to achieve significant advances in the generation, transmission, conversion and utilization of energy in space. Through this work, promising concepts are systematically explored, and the critical technologies involved in determining fundamental feasibility are generated. This work is necessary to provide the underlying understanding required to advance our capability to explore and use space. Potential advantages of laser power transmission, such as central power stations, orbital transfer vehicle propulsion, earth-to-orbit propulsion, and power relays in space, are possible with efficient low-cost space-based laser systems. Work on laser pumping schemes and receiver technology is being conducted to establish the fundamental understanding required to demonstrate such potential advantages.

SPECIFIC OBJECTIVE

TITLE: Electric Propulsion Technology

Program/Discipline Objective Title: Space Energy Conversion R&T

Responsible Organization/Individual: Aerospace Research Division/W. Hudson

SPECIFIC OBJECTIVE:

To develop the technology for future electric propulsion systems including thrusters and associated power processors for application to Earth orbital and planetary missions.

- Platform:

  Provide a technology base for electrothermal propulsion systems applicable to drag makeup for near-term and far-term space stations.

  Provide an ion thruster technology base for future large space structure auxiliary propulsion and for intermediate and geosynchronous on-orbit propulsion.

- Generic:

  Perform fundamental research into life limiting processes of magnetoplasmadynamic thrusters, ion bombardment thrusters, electrothermal thrusters and electromagnetic thrusters.

TARGETS:

- During FY 1983, complete study of the on-orbit and orbital-transfer propulsion technology options for large space structures.
- During FY 1983, complete the performance documentation on an inert gas laboratory thruster for Earth-orbital applications.
- Complete, by the end of FY 1984, an operating life verification of the inert gas thruster technology.
- Demonstrate rail gun projectile velocities of 20 km/sec by the end of FY 1984.
- During FY 1985, initiate the prototype inert gas thruster design.

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- o Complete the technology development of an advanced large-scale beam extraction system by the end of FY 1985.
- o During FY 1986, complete an inert gas laboratory system demonstration.
- o During FY 1986, complete an NEP thrust subsystem design.
- o Complete technology readiness program of a one Newton, 5 KW, H_2 resistojet in FY 1987.
- o Complete MPD laboratory system demonstration in FY 1987.

JUSTIFICATION:

High specific impulse propulsion systems will be required for the energetic missions of NASA's exploration of the solar system, as well as for on-orbit and orbital transfer propulsion applications, in near-Earth space. For many of these missions, electric propulsion can substantially reduce overall system weight, increase payload capability, and reduce trip time. This technology effort provides for the continuing evolution of electric propulsion to higher thrust and power levels, lower specific mass, and broader operating regions. A research program directly supports the technology effort in electric propulsion and provides the basis for continuing advancement. Ultimately, there is the potential for the development of nuclear electric propulsion systems. Such a propulsion system would be independent of the solar intensity and it would be enabling for the extensive exploration of the outer planets.

SPECIFIC OBJECTIVE

TITLE: Photovoltaic Energy Conversion

Program/Discipline Objective Title: Space Energy Conversion R&T

Responsible Organization/Individual: Aerospace Research Division/D. Flood

SPECIFIC OBJECTIVE:

To improve conversion efficiency, reduce mass, reduce cost, and increase operating life of photovoltaic converters and arrays.

- Generic:

  Develop and apply an improved understanding of photovoltaic energy conversion, and evaluate a broad range of advanced concepts for reducing cost and mass of photovoltaic systems.

- Platform:

  Develop photovoltaic energy conversion technology to reduce cost and mass and increase operating lifetimes of solar cells and blankets.

- Spacecraft:

  Determine, select, and develop solar cell, blanket, and array technologies that will provide the capability for a low-cost, long-life photovoltaic energy source for Earth-orbiting missions in HEO/GEO and for future planned planetary missions. Emphasis to be directed to requirements of HEO/GEO missions.

TARGETS:

- Demonstrate 15% damage in Si solar cells after 10 years in GEO in FY 1983.
- Fabricate 14%, 10-micron-thick GaAs solar cell by end of FY 1983.
- Decide between spectro-and thermo-photovoltaic technology in FY 1983.
- Complete laboratory demonstration of 300 kW array technology by end of FY 1984.
- Demonstrate technology for $>$ 150 W/kg planar Si array for GEO by end of FY 1984.

- Conduct laboratory demonstration of 30%-efficient solar cell in FY 1984.
- Demonstrate 200/W GaAs cell technology in FY 1984.
- Fabricate and test 19%-efficient GaAs cell at 100X, 80°C in FY 1985.
- Demonstrate > 300 W/kg array structure in FY 1985.
- Demonstrate GaAs solar cell technology which exhibits no more than 10% degradation of effeciency after an equivalent 10 years radiation in synchronous orbit in FY 1985.
- Demonstrate 18%-efficient thin-film GaAs solar cell in FY 1986.
- Demonstrate 15% Si EOL efficiency after 10 years in GEO in FY 1986.
- Conduct laboratory demonstration of 50%-efficient solar energy conversion concept by end of FY 1986.
- Complete blanket technology for >300 W/kg planar silicon array by end of FY 1986.
- Demonstrate silicon solar cell welding interconnect technology capable of withstanding 60,000 LEO temperature cycles by end of FY 1986.
- Demonstrate radiation tolerant 30% solar cell in FY 1987.
- Fabricate GaAs concentrator cell with 21% AMO efficiency at 100 suns and 80°C in FY 1987.

JUSTIFICATION:

Projected agency mission needs will place increasing reliance on photovoltaic systems to supply their energy requirements. Total energy needs are expected to increase greatly as near-Earth space is developed and the solar system is explored with greater intensity. The performance of these systems must be improved and their cost reduced, if these needs are to be satisfied. This research aims at critical component advances consistent with those ends.

SPECIFIC OBJECTIVE

TITLE: Chemical Energy Conversion and Storage

Program/Discipline Objective Title: Space Energy Conversion

Responsible Organization/Individual: Aerospace Research Division/J. Ambrus

SPECIFIC OBJECTIVE:

To develop critical technologies in electrochemistry which will lead to advanced primary and secondary battery and fuel cell systems.

- Generic:

  To develop basic understanding of chemical and electrochemical processes governing the performance and life of electrochemical cells and batteries.

- Platform:

  To develop technology of very high-capacity, long-life, high-energy-density electrochemical energy conversion and storage systems (batteries and fuel cells).

- Spacecraft:

  To develop the technology base for very high-energy-density, long-life, electrochemical energy storage systems for LEO and GEO.

TARGETS:

- Complete breadboard testing of fuel cell/electrolyzer energy storage system (SPE) by end of FY 1983.
- Determine feasibility of advanced electrochemical storage devices. Define materials, processes, and systems by end of FY 1983.
- Complete component selection and design high-capacity NiH_2 cell by end of FY 1983.
- Complete advanced alkaline electrolysis stack (1 square foot) by end of FY 1983.
- Complete the synthetic battery cycling analysis of high-energy-density sodium sulfur batteries for GEO applications by end of FY 1983.
- Complete breadboard testing of alkaline fuel cell/electrolyzer system by end of FY 1984.

- Select components of high-energy-density secondary electrochemical cell (lithium anode) by end of FY 1984.

- Show acceptable electrolyte volume management within a working multiplate cell using the principles of pore size engineering by end of FY 1984.

- Commence endurance testing of selected advanced fuel cell components in FY 1984.

- Obtain fundamental understanding of performance characterization and failure mechanism of primary lithium cells by end of FY 1985.

- Deliver engineering model of selected fuel cell/ electrolyzer system by end of FY 1986.

- Construct and demonstrate prototype primary lithium cells that are safe for NASA applications with energy density of 300 whr/kg and operable at the 1-hr. discharge rate by end of FY 1986.

- Test suitability of lightweight (50% weight reduction) Ni electrode structure for bipolar application by end of FY 1986.

- Complete testing of engineering model of fuel cell/ electrolyzer system by end of FY 1987.

- Construct and demonstrate engineering model of secondary lithium cell with energy densities of 200 whr/kg for GEO and 70 whr/kg for LEO by end of FY 1987.

- Publish specification for flight quality lithium primary cell by end of FY 1987.

- Ensure NiH_2 high-capacity technology readiness by end of FY 1987.

JUSTIFICATION:

Advanced spacecraft batteries with life of ten years or greater and improved energy density are required if future difficult missions are to be accomplished. To enable probe and extraterrestrial lander missions, high-performance batteries with long life are needed. Increased capacity batteries and/or fuel cell/electrolysis systems will be required if we are to provide high-capacity systems needed for use in near-Earth space. This research is aimed at meeting these needs.

SPECIFIC OBJECTIVE

TITLE: Thermal-to-Electric Conversion

Program/Discipline Objective Title: Space Energy Conversion R&T

Responsible Organization/Individual: Aerospace Research Division/J. Ambrus

SPECIFIC OBJECTIVE:

To provide thermal conversion technology which can be used with either nuclear or solar energy sources that is cost and mass competitive with solar arrays or is required in applications for which alternatives are impractical.

- Generic:

  Demonstrate the feasibility of a prototype thermal-to-electric conversion system for solar independent high-power application (SP-100).

  Develop advanced highly efficient (Avg. $Z \geq 1 \times 10^{-3}$) thermoelectric conversion alloys capable of operating at high temperatures (1600K) for long periods of time (≥ 7 years).

- Spacecraft:

  Demonstrate the feasibility of low-temperature (1300K) highly efficient (Avg. $Z \geq 1 \times 10^{-3}$) thermoelectric energy conversion devices for radioisotope thermoelectric generator (RTG) application.

TARGETS:

- Select radiator material thermal insulation and structural design concept by the end of FY 1983.
- Demonstrate an N & P thermoelectric alloy with an average figure of merit (Z) of greater than 1×10^{-3} by the middle of FY 1983 (1600K maximum temperature).
- Demonstrate a lightweight multicomponent thermopile by the end of FY 1984.

- o Select bonding and contacting method by the end of FY 1984.
- o Demonstrate an N & P thermoelectric alloy with an average figure of merit (Z) equal to or greater than 1×10^{-3} by the end of FY 1983 (1300K maximum temperature).
- o Demonstrate high-temperature (1600K) N & P couple by end of FY 1985.
- o Demonstrate prototype SP-100 T/E panel by the end of FY 1986.
- o Identify alloy degradation mechanisms and process by end of FY 1986.
- o Demonstrate successful bonding and contact method to selected low-temperature alloy by the end of FY 1986.
- o Demonstrate long-term ($\geq$ 7 years) operational stability of high-temperature alloy system by end of FY 1987.

JUSTIFICATION:

High-power ($>$10kW), high-efficiency thermoelectric conversion, when coupled with solar or nuclear energy sources, offers the potential of both systems and cost advantages over high-power solar photovoltaics. Thermal systems are also required for operation in hostile environments or under conditions in which access to the sun is limited and also to achieve nuclear electric propulsion. Technology for these systems is both primitive and costly at the present time. This research aims at advancing these technologies to the point where their potential advantages can be realized in future NASA missions.

Isotope power systems will continue to be required by future NASA missions for which solar power systems are impractical. If these systems are to be used at power levels above 500 watts, their cost must be reduced to acceptable levels through the development of more efficient thermoelectric conversion systems.

SPECIFIC OBJECTIVE

TITLE: Power Systems Management and Distribution

Program/Discipline Objective Title: Space Energy Conversion R&T

Responsible Organization/Individual: Aerospace Research Division/Wayne Hudson

SPECIFIC OBJECTIVE:

To provide the technology base necessary to control the generation and distribution of energy in future space systems, and to assure their environmental compatibility.

- Platform:

  Provide the components, advanced devices, and subsystems for high power management and distribution including power electronic components, heat pipes, radiators, rotary joints, transmission lines, and automation technology.

  Provide guidelines for spacecraft designers on high-voltage space plasma interactions.

- Generic:

  Provide fundamental research for advanced dielectric materials, future device feasibility (rectenna), deep trapped devices and diamond films.

TARGETS:

- Complete infrared rectenna technology development plan in FY 1983.
- Complete diamond film technology program plan by the end of FY 1983.
- Complete, by the end of FY 1983, an AMPS Multi-KV demonstration.
- Complete, by the end of FY 1983, a technology program leading to a 1000V, 120A power transistor.
- Complete, by the end of FY 1984, analytical modeling of large structure and high-voltage surface interactions.

- o Complete prototype constructable radiator panel fabrication and test by FY 1984.
- o By the end of FY 1985, complete 100 kW, 1KV breadboard transmission line.
- o Complete 50-Watt-hour/kg flywheel demonstration in FY 1985.
- o Build and map the performance of a prototype heat pipe system capable of 100 kW-m heat transfer at 20^{o}C by the end of FY 1985.
- o Complete analytical model power systems application studies by the end of FY 1986.
- o Complete technology readiness of autonomously managed power system in FY 1986.
- o Develop and verify a synthesized AC/DC analytical model for spacecraft power systems by the end of FY 1986.
- o Complete final Plasma Interaction Design Guidelines by the end of FY 1987.

JUSTIFICATION:

Analyses of future planetary and geosynchronous applications have identified a variety of power systems requirements. They include total energies two to three orders of magnitude greater than past missions, automated power systems for long-life operation in hostile environments, and high-voltage systems to achieve high performance.

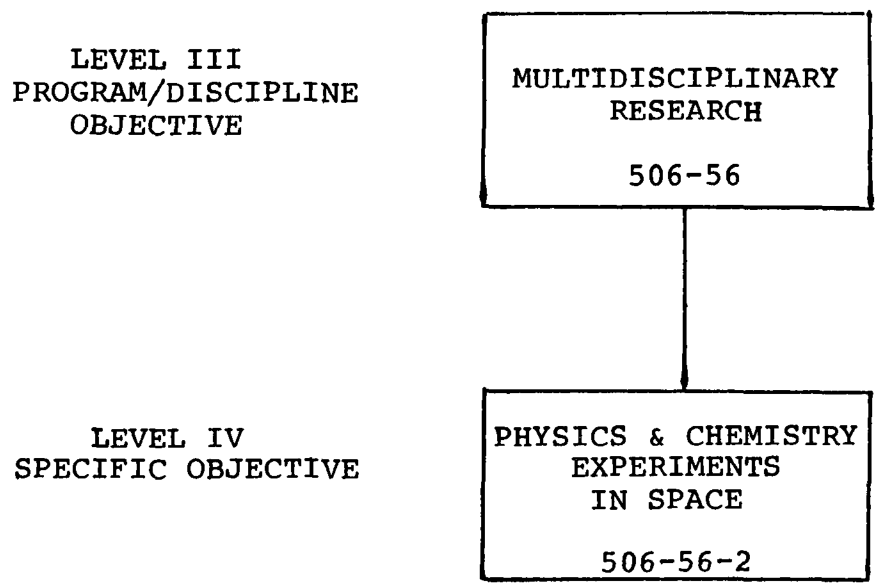
If future missions are to be carried out, two important problems must be solved: First, system elements capable of meeting the power demands for the required durations must be provided and, second, the specific cost must be reduced to accceptable levels.

8

MULTIDISCIPLINARY RESEARCH

MULTIDISCIPLINARY RESEARCH WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Multidisciplinary Research

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Aerospace Research Division/Judith Ambrus

PROGRAM/DISCIPLINE OBJECTIVE:

To conduct basic research of science and engineering interest to advanced space technology.

SPECIFIC OBJECTIVE:

- Physics and Chemistry Experiments in Space: To define and develop experiments in physics and chemistry that employ the unique characteristics of the space environment and increase the fundamental knowledge about material properties processes.

SPECIFIC OBJECTIVE

TITLE: Physics and Chemistry Experiments in Space

Program/Discipline Objective Title: Multidisciplinary Research

Responsible Organization/Individual: Aerospace Research Division/Judith Ambrus

SPECIFIC OBJECTIVE:

Generic:

To define and develop experiments in physics and chemistry that employ the unique characteristics of the space environment and increase the fundamental knowledge about materials properties or processes.

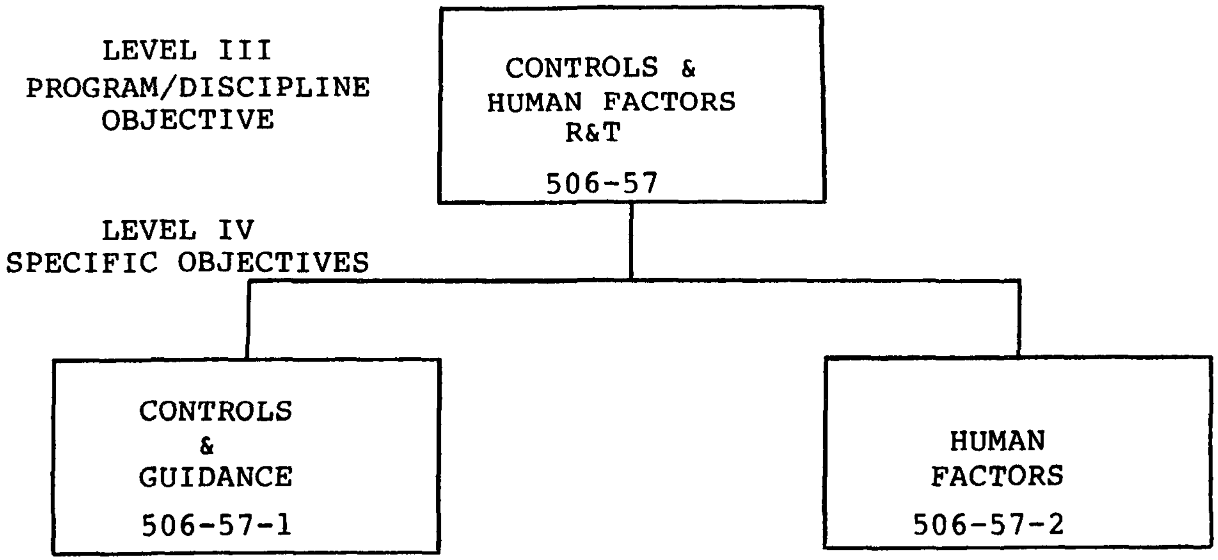
JUSTIFICATION:

The Shuttle and Spacelab offer the unique opportunity to conduct experiments in space to advance basic knowledge in physics and chemistry. The space environment including near-weightless, high-vacuum, varying gravitational potential, low temperature, and solar wind has been shown to be useful in conducting basic research in drop dynamics, quantum fluids, combustion, geophysical fluid flow, and other fields of physics and chemistry. By funding experimental and theoretical research and definition studies, under the careful selection process of the Physics and Chemistry Experiments Working Group, OAST provides the opportunity for scientists to consider the prospects of performing research in space and to develop a preliminary program plan, where one is warranted.

9

CONTROLS AND HUMAN FACTORS R&T

CONTROLS AND HUMAN FACTORS R&T WORK BREAKDOWN STRUCTURE
LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Controls and Human Factors R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Aerospace Research Division/Herman A. Rediess

PROGRAM/DISCIPLINE OBJECTIVE:

To provide advanced controls and guidance technology and human factors principles that will allow the design of future space vehicles, platforms, and other spacecraft with significantly improved performance, endurance and operational efficiency, or with increased mission capability. The program is to develop fundamental understanding and design analysis methodology, as well as focused disciplinary research specific to space transportation, spacecraft, and space station requirements.

SPECIFIC OBJECTIVES:

- Controls and Guidance: To develop design concepts, analysis and testing techniques, and advanced components for controlling and guiding earth-orbiting spacecraft including large antennas, platforms, payloads and experiments, space transportation vehicles, and planetary spacecraft.

- Human Factors: To develop a technology base for optimal allocation of functions to humans and to automation, and for designing maximally effective, efficient and safe roles, work stations, tools, and procedures for use in space operations.

SPECIFIC OBJECTIVE

TITLE: Controls and Guidance

Program/Discipline Objective Title: Controls and Human Factors R&T

Responsible Organization/Individual: Aerospace Research Division/John B. Dahlgren

SPECIFIC OBJECTIVE:

To develop design concepts, analysis and testing techniques, and advanced components for controlling and guiding earth-orbiting spacecraft including large antennas, platforms, payloads and experiments. space transportation vehicles, and planetary spacecraft.

- Generic:

  To derive new concepts and approaches to effective control of large dynamic structures

  - Real-time adaptive/learning and self-reorganizing control algorithms for large space structures
  - On-line system identification of large, flexible space structures with changes in configuration
  - Control of nonlinear partial differential equation systems

- Transportation:

  To develop advanced control and guidance concepts for current and future transportation systems which are more technically efficient and which lead to more cost-affordable future space transportation missions.

  - Advanced technology for on-orbit control of modular dynamic bodies through expanded STS control envelope.
  - Design technology for integration of distributed flight control and data processing systems into highly reliable fault-tolerant vehicle operation providing for evolutionary improvements and upgrading without significantly impacting costs.

- Spacecraft:

  To develop advanced concepts and techniques for controls, precision pointing, and stability and guidance and navigation of large antennas, precision reflectors, and advanced Earth-orbital spacecraft.

  - Precision pointing, stabilization, and figure control of large flexible reflectors.
  - Technology validation through ground testing and Shuttle-based and/or free-flyer control experiments.
  - Advanced solid-state sensor development for guidance and control.

- Platform:

  To advance the understanding and state of the art in pointing and stabilization of large systems controls, multibody guidance and controls, and advanced guidance and control devices.

  - Control of modular bodies and multiple payload interactive systems.
  - Advanced systems identification, and model order estimation and compensation.
  - Control of distributed/decentralized systems.
  - Autonomous momentum management.
  - Multiple platform control and sensing for rendezvous and docking.

TARGETS:

- Develop the control system concepts using distributed sensor and actuator techniques to accurately point and control large, flexible, deployable or assembled antennas and platforms - FY 1983
- Verify advanced control techniques for large, highly flexible spacecraft using two-dimensional flexible plate in laboratory experiment - FY 1984
- Complete development and testing of advanced long-life angular sensor and inertial measuring system concepts for potential use in spacecraft guidance systems or large space structure control systems - FY 1984

- o Verify design and analysis techniques for control of distributed systems through laboratory experiments - FY 1985

- o Develop a methodology to assess both the STS control capability and characteristics of the potential STS cargoes which affect controllability, and identify techniques to expand/improve the controls envelope - FY 1985

- o Develop the definition of, and the design for, a Shuttle/antenna controls experiment to validate concepts and techniques for control of large flexible structures - FY 1986

- o Demonstrate the technology readiness for control and guidance of large modular interactive platforms during berthing, deployment, and assembly, including advanced system identification, adaptive control techniques, model order estimation, distributed control systems implementations and required guidance and control sensors and actuators - FY 1986

- o Develop a methodology that utilizes the STS capabilities to attain design requirements for retrieval systems and satellite services, and evaluate guidance and control techniques to achieve proximity operations and maneuvering for such retrieval systems - FY 1986

- o Develop an advanced fine guidance sensor with a very large dynamic range, compared to the telescope angular resolution, to enhance the acquisition and tracking of guide stars - FY 1986

- o Develop STS design concepts and techniques for onboard electronics, data processing and interactive software which integrate the control, overall systems management, and vehicle operation functions into highly reliable fault-tolerant systems - FY 1987

- o Develop advanced guidance, navigation, and control approaches to provide the desired maneuver capability for OTV aerodynamically assisted trajectories - FY 1988

JUSTIFICATION:

Planned and projected missions will require spacecraft that are larger, loosely coupled structural systems which may be highly flexible because of the cost of delivering mass to orbit. Such spacecraft, including space platforms, large antennas, and space station, present formidable and as yet unsolved problems in control system design which must be addressed while at the same time requiring higher performance than current systems. Therefore, these spacecraft will require development of new enabling design concepts and techniques. This program provides the focus for new areas of controls and guidance research and advanced development with emphasis on: distributed control concepts for shape and vibration control; advanced modeling techniques for control system design and synthesis; adaptive/learning systems to increase performance and fault tolerance; advanced control sensors (guidance, altitude, velocity, vibration, deflection) and actuators (vibration dampers, large long-life momentum devices), and development of analytical and experimental techniques to validate the technology.

For current space transportation systems (STS) significant challenges remain regarding flight control with attached dynamic bodies. New cost-efficient, highly reliable design approaches are required to remove the inadequacies in flight, to provide multiple functions and accommodate a wide spectrum of configurations and disturbances. Solutions which extend the control capability, while reducing costly software development, must be pursued through early technical integration of the involved disciplines such as structure and dynamics with controls and software approaches providing reliable, modular and distributed flight control.

SPECIFIC OBJECTIVE

TITLE: Human Factors

Program/Discipline Objective Title: Controls and Human Factors R&T

Responsible Organization/Individual: Aerospace Research Division/Melvin D. Montemerlo

SPECIFIC OBJECTIVE:

To develop a technology base for optimal allocation of functions to human and to automation, and for designing maximally effective, efficient and safe roles, work stations, tools, and procedures for use in space operations.

- Generic:

  To develop human factors techniques, methods, data bases, and standards for the design and and evaluation of man/machine interfaces for use in space operations.

- Transportation:

  To develop programs for advancing human factors technology for current and future transportation systems.

  - For crew/vehicle interaction, develop methods and techniques for using advanced display and control technology (e.g., flat panel displays, touch-sensitive panels, voice-recognition synthesis, etc.) for developing more efficient vehicle crew-station designs. Develop techniques for integrating multifunction display requirements into advanced graphic/alphanumeric display control systems.
  - Develop an anthropomorphic data base capability for crew-station layout design which can be applied to Earth-to-orbit (ETO) and orbital transfer vehicle (OTV).

- Platform:

  To develop human factors technology for improvement of crew/machine interaction within and surrounding the platform.

  - Develop extra-vehicular activity (EVA) human factors technology for equipment, suit and tool design, restraint and mobility, and on-orbit operations task allocation between crew and automated systems and EVA techniques.

- Develop human factors technology for teleoperator/human interface, including augmented sensory feedback for direct and supervisory control of teleoperators.
- Develop analytical methods to evaluate human interface with intelligent systems, develop requirements for control panel and display designs.
- Develop advanced crew-station design guidelines.

TARGETS:

o Establish state of the art, technology needs, and capabilities to research and develop design and evaluation tools and techniques for space human factors discipline applications (e.g., crew workload and performance measures, anthropomorphic data bases, man-machine task allocation functions, etc.) - FY 1983

o Publish assessment of state of the art and future requirement, and five-year plan for research in:

- teleoperators human factors
- EVA human factors
- space transportation crew-station design
- space station crew-station design
- human-computer interface

FY 1983

o Establish a capability for conducting fundamental and applied research on human capabilities and limitations in:

- teleoperations
- EVA
- space transportation system flight management
- human operations onboard space stations
- human/computer interface

FY 1983

o Establish a university-based center of excellence in research on sensory-motor effects of the on-orbit

task and tool design which cause disorientation - FY 1983

- o Determine human capabilities/limitations in teleoperations (e.g., endurance, time delays, perceptual and cognitive limits, etc.) - FY 1985

- o Develop design guidelines for teleoperator procedures (e.g., supervisory control strategies, procedures for handling long feedback delays and various end effects, etc.) - FY 1985

- o Develop human factors design guidelines for advanced extra vehicular activity (EVA) tools (e.g., power takeoff, torque wrenches, extenders, end-effectors, etc.) work stations (e.g., foot restraints, tethers, etc.), and job aids (e.g., force feedback device, portable computerized trouble-shooting aids, etc.) - FY 1985

- o Develop equipment/structure design guidelines for EVA maneuverability (e.g., grapples, hand-holds visual access, module changeout, instrument insertion, etc.) and for EVA assembly (e.g., fastness, connectors, capture features, grapples, etc.) - FY 1985

- o Develop human factors guidelines for design of teleoperator control stations (e.g., anthropomorphic design, command and display mechanisms, etc.) - FY 1986

- o Develop techniques to provide enhanced sensory feedback to teleoperator (human) operator (e.g., force feedback, stero-vision, augmented graphic displays, etc.) - FY 1986

- o Develop human factors design guidelines for space suit and man-maneuvering unit suit (MMU) man/machine interfaces (e.g., gloves, tool storage, lighting, etc.) - FY 1986

- o Develop design guidelines for operational procedures to be used in EVA tasks (e.g., maintenance, inspection, assembly, alignment, deployment, retraction, transfer, etc.) - FY 1986

- o Develop human/computer interface design guidelines for computer systems to be used in space operations and maintenance - FY 1986

- o Develop technology for using advanced display and command technology (e.g., flat panel displays, touch panels, voice actuation/synthesis, etc.) for improving space transportation and platform crew stations - FY 1986

JUSTIFICATION:

The affordability, capability and safety of manned space operations in the next two decades will depend on an optimal allocation of tasks to humans and to automation. While automation can perform some tasks more precisely than humans, the cost and lead times for its development are prohibitive in many cases, especially for infrequently performed tasks. A second overriding factor requiring the use of humans is that they are far more flexible than automation in coping with unforseen problems and in taking advantage of unforseen opportunities.

Human operations in space will be of three types: (1) "hands-on" tasks (crew stations can be of the flight management type such as the shuttle cockpit, or of the experiment/housekeeping/work station type such as on Skylab); (2) remotely performed tasks accomplished by means of a teleoperator; and (3) "hands-on" tasks performed in the EVA environment. The need for human factors design and evaluation methodologies to develop tools, man/machine interfaces and operational procedures for these three types is as follows:

Crew Station - Advanced technology has been developed for input and display of information at crew stations in aircraft, ships, power generation control rooms, and other applications which could well be used in space station and space transportation crew stations. These technologies include: flat panel displays, touch-sensitive panels, multifunction programmable keyboards, voice recognition/synthesis, etc. However, adaptation of these technologies in an effective, efficient, safe manner will require development of methods for integrating, condensing, coding and displaying data in a manner consistent with human perceptual and cognitive capacities. Opportunities to apply new and advanced technology will be manifested with a manned OTV system which is expected to become operational about 1995. Advanced human factors technology may have application opportunities with subsequent orbiter procurements (post OV-105). A second generation ETO launch system (IOC post-2000) will be human factors configured.

Teleoperations - Teleoperations has been developed within NASA in the form of the Space Shuttle's Remote Manipulator System (RMS). However, this is only a first step toward the capability for remote operations needed to reduce the cost and risk of assembly and maintenance of space systems. Before

humans can use teleoperators for fine manipulations on a wide spectrum of tasks, the technology must be developed to provide the human operator with increased sensory feedback and with improved methods of supervisory control.

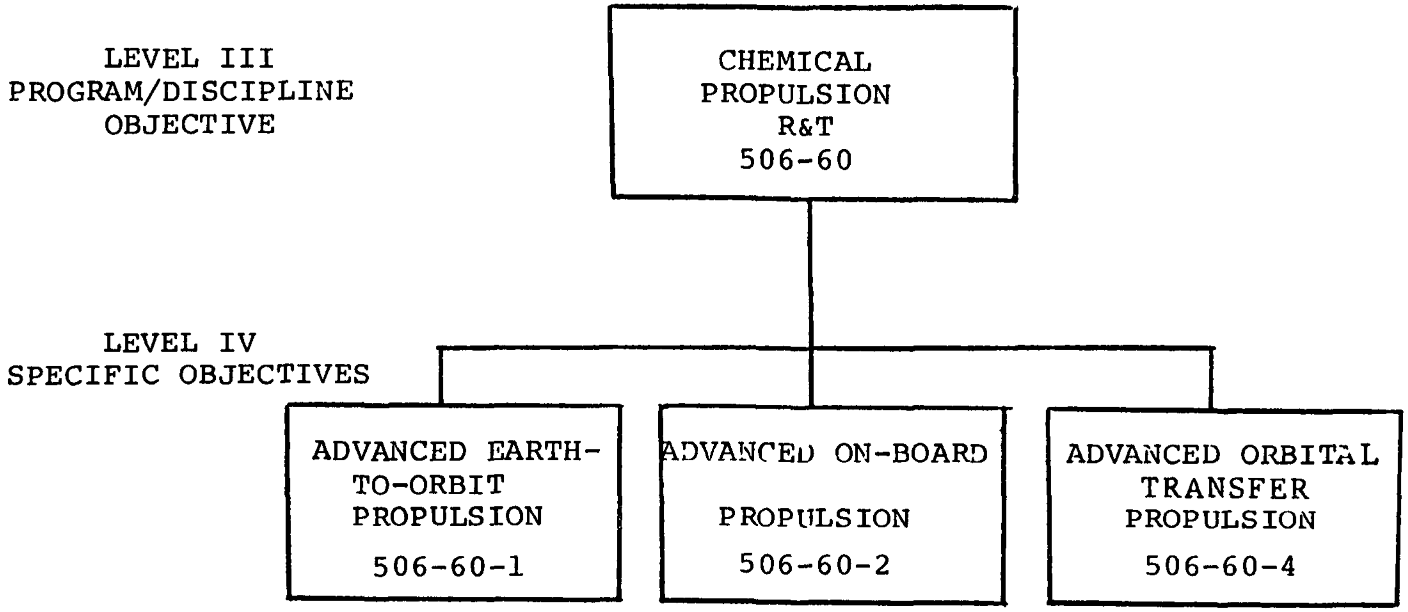
EVA - Until intelligent multifunction robots are developed, or even until increased sophistication is available for teleoperations, the only alternative for performing many tasks in space will be by sending astronauts into the often hostile EVA environment. However, because of vision and mobility constraints on an astronaut in a space suit, his capability to perform tasks is severely limited. To cut the costs and risks of EVA operations, improved tools and procedures will have to be developed based on a fundamental knowledge of human physical and psychological capabilities and limitations.

NASA has recently begun to address the next logical step in the U.S. space program -- the permanent presence of humans in space. This will undoubtedly take the initial form of a manned space station in low Earth orbit. Yet, the technology dealing with long duration stay-times of humans in space has received relatively little attention since the Apollo and Skylab missions. A systematic program to identify and develop needed technology to support man-in-the-loop space operations is necessary in order to maximize the affordability and capability of a space station and to minimize its risk.

CHEMICAL PROPULSION R&T

CHEMICAL PROPULSION R&T WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Chemical Propulsion R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Edward A. Gabris

PROGRAM/DISCIPLINE OBJECTIVE:

To provide the propulsion research and technology base for lower cost reusable Earth-to-orbit space transportation systems; for long-life Earth-orbiting spacecraft and platforms; and for more versatile and higher performing orbital transfer vehicles.

SPECIFIC OBJECTIVE:

- Advanced Earth-to-Orbit Propulsion: To extend the technology for advanced reusable propulsion systems in the areas of operational life and performance, servicing and maintenance, and condition monitoring in order to build on the technology base established by the SSME and help simplify and reduce the cost of current and future reusable Earth-to-orbit (ETO) vehicle operations.

- Advanced On-Board Propulsion: To provide the technology for advanced on-board spacecraft propulsion systems that will provide performance necessary to minimize propulsion system mass or reduce propellant resupply requirements; that will minimize potential contamination of other on-board subsystems and/or scientific instruments; and that will operate intermittently and reliably for many years.

- Advanced Orbital Transfer Propulsion: To provide the technology for highly versatile, high-performance propulsion systems that offer increased mission capability and flexibility while performing orbital transfer missions reliably and at reduced cost.

SPECIFIC OBJECTIVE

TITLE: Advanced Earth-to-Orbit Propulsion

Program/Discipline Objective Title:
Chemical Propulsion R&T

Responsible Organization/Individual: Space Systems Division/Frank W. Stephenson

SPECIFIC OBJECTIVE:

To extend the technology for advanced reusable propulsion systems in the area of operational life and performance, servicing and maintenance, and condition monitoring, in order to build on the technology base established by the SSME and help simplify and reduce the cost of current and future reusable Earth-to-orbit (ETO) vehicle operations.

o Generic:

To extend fundamental knowledge in basic chemical and physical processes that occur in rocket propulsion systems in order to extend operational service life and to increase performance with maximum reliability. Emphasis will be on developing analytical models and verifying them experimentally in the areas of bearing life, turbine flow dynamics, rotor dynamics, combustion and heat transfer, and in high-cycle and low-cycle fatigue life predictions and extensions.

o Transportation:

To provide the technology base for long-life high-performance high-pressure oxygen/hydrogen and oxygen/hydrocarbon primary and auxiliary propulsion systems including upgrading of SSME performances and life. Principal focus will be on developing a comprehensive understanding of the environments in which engine components must operate; on developing approaches for alleviating the operating environment and/or establishing new component design concepts capable of withstanding the operating environments;

and on demonstrating that effective solutions to these technology problems have been found.

TARGETS:

- o Complete low leakage seal model - FY 1983.
- o Establish oxygen-hydrocarbon preburner ignition/combustion performance and computer models - FY 1984.
- o Establish oxygen-hydrocarbon combustion performance and computer models for main combustor - FY 1984.
- o Complete uniform duct flow model - FY 1984.
- o Complete transient nozzle flow model - FY 1984.
- o Improved preburner ignition/combustion performance, durability - FY 1985.
- o Establish turbine blade ceramic coating processes/performance - FY 1985.
- o Demonstrate improved material compatibility with hydrogen - FY 1985.
- o Demonstrate oxygen regenerative cooling of oxygen-hydrocarbon combustion chambers - FY 1985.
- o Establish hydrocarbon fuel heat transfer characteristics, including coking - FY 1985.
- o Establish heat transfer characteristics and computer models for high-pressure oxygen-hydrocarbon combustors - FY 1985.
- o Establish high-cycle fatigue life prediction capability - FY 1986.
- o Expand combustion stability computer models to include high-pressure oxygen-hydrocarbon propellants - FY 1986.
- o Complete transpiration cooling model - FY 1986.
- o Demonstrate diagnostic system and in-place inspection capability - FY 1987.

- o Demonstrate long-life bearings and seals for high-pressure hydrocarbon fuel pumps - FY 1987.
- o Establish combustion performance and computer models for dual fuel combustors - FY 1989.

JUSTIFICATION:

In order to take full advantage of the opportunities that space has to offer in the future, the cost of delivering payloads into Earth orbit needs to be significantly reduced compared to the expendable launch vehicles used in the past. The Space Shuttle has taken a major step toward reducing these costs by introducing reusable elements into the Earth-to-orbit delivery system. Efforts need to be addressed that will help reduce Space Shuttle operational costs and that will also be applicable to reusable Earth-to-orbit vehicles of the future.

The Space Shuttle Main Engine (SSME), which powers the orbiter vehicle, is one of the reusable elements that is contributing to lower Earth-to-orbit transportation costs. The technology level achieved by the SSME represents a base from which future reusable oxygen-hydrogen or oxygen-hydrocarbon engines can and should grow, including upgraded versions of the SSME and its derivatives. Significant extensions in maintenance-free operational service life, including critical component high-cycle, low-cycle fatigue life, enhanced engine performance, technologies leading to automated diagnostics capability for engine condition monitoring, and in-place inspection techniques will provide the new level of engine technology needed for further significant reductions in Earth-to-orbit transportation costs.

Technology will be developed for high-speed, high-pressure turbomachinery, hot gas flow components, condition monitoring sensors and sensing techniques, and in materials and advanced fabrication methods. The technology advances will be directed initially toward increased component life and later toward performance improvements.

SPECIFIC OBJECTIVE

TITLE: Advanced On-Board Propulsion

Program/Discipline Objective Title:
Chemical Propulsion R&T

Responsible Organization/Individual:
Space Systems Division/Frank W. Stephenson

SPECIFIC OBJECTIVE:

To provide the technology for advanced on-board spacecraft propulsion systems that will provide performance necessary to minimize propulsion system mass or reduce propellant resupply requirements; that will minimize potential contamination of other on-board subsystems and/or scientific instruments; and that will operate intermittently and reliably for many years.

- Generic:

  To evaluate advanced propulsion concepts that give promise of greatly exceeding the performance capabilities of conventional chemical propulsion systems. Research needed to establish the feasibility of the most promising concepts will be identified. Candidate concepts include free radicals, metastables, atomic species, and chemical/electric hybrids.

- Platform:

  To evaluate and advance critical technologies to establish technology readiness for space station propulsion systems designed to provide attitude control, drag makeup, and acceleration control. Candidate propulsion systems include monopropellant hydrazine, bipropellant hydrazine-fueled systems, gaseous oxygen-hydrogen and resistojets. Technology is needed to address problems concerning how to minimize the propulsion system contribution to space station contamination while maintaining a high level of performance to minimize resupply requirements along with simplicity to promote reliability, minimum front-end costs and to reduce repair, servicing, and maintenance requirements.

TARGETS:

- Establish baseline system designs - FY 1983

- Determine relative contamination potential of nozzle effluent species - FY 1983

- Establish thruster performance vs. contamination relationships - FY 1985
- Establish relationship between system performance and system complexity, reliability, maintainability, and cost - FY 1985
- Establish optimized system design - FY 1986
- Demonstrate component performance - FY 1986
- Complete evaluation of component interactions - FY 1987

JUSTIFICATION:

Earth-orbiting space stations and satellites, and planetary spacecraft require multithrust propulsion capability to provide such functions as attitude control, orbital maneuvers (orbit insertion, drag makeup, etc.), and acceleration control for zero gravity experiments. In order to minimize the impact of on-board propulsion on the spacecraft itself, desirable characteristics include a high level of performance, minimum contamination potential, and long service life with minimum servicing and maintenance. In addition, reduced life-cycle costs along with low front-end costs are also desirable.

An early application of this technology could be a manned orbiting space station. A number of attractive propulsion system candidates have been identified that could provide the needed propulsion capability. However, system definition, technology identification, and trade-off studies backed by critical technology advances are needed to determine those systems that best meet space station requirements, and will also provide growth potential needed as the space station evolves and expands after it is initially placed in low Earth orbit.

SPECIFIC OBJECTIVE

TITLE: Advanced Orbital Transfer Propulsion

Program/Discipline Objective Title:
Chemical Propulsion R&T

Responsible Organization/Individual:
Space Systems Division/Frank W. Stephenson

SPECIFIC OBJECTIVE:

To provide the technology for highly versatile, high-performance propulsion systems that offer increased mission capability and flexibility while performing orbital transfer missions reliably and at reduced cost.

o Generic:

To extend fundamental knowledge in rocket engine turbopumps and combustors through a program in basic research designed to analytically model and experimentally verify pump hydrodynamics and thruster combustion and heat transfer processes over a wide range of operating conditions. In addition, analytical models will be developed and experimentally verified for very high expansion ratio internal nozzle flow, and for external nozzle plume flow under vacuum conditions.

o Transportation:

To provide the technology base for high performance, multiple restart, variable thrust orbital transfer propulsion systems through a combined program of engine design and trade-off studies and supporting technologies. Long-life bearings and seals capable of operating over a wide range of shaft speeds, pressures, and temperatures; high-performance combustors capable of transferring high rates of heat transfer to the turbine working fluid for increased combustion pressure operation; and highly efficient variable flow turbopumps are among those technologies already identified as needed to verify concept feasibility. Other critical technologies will be pursued as they are identified in the design studies.

TARGETS:

- o Establish initial advanced OTV engine conceptual designs - FY 1982.
- o Evaluate propellant management concepts for for low-thrust vehicles and identify technology need - FY 1983.
- o Develop analysis and computer models for high heat transfer oxygen-hydrogen combustors - FY 1983.
- o Develop long life, cryogenic service, bearing and seal technology - FY 1984.
- o Establish capability of very small dynamic and positive displacement pumps for use with cryogenics - FY 1984.
- o Establish ignition/combustion performance and computer models for small oxygen-hydrogen combustors - FY 1985.
- o Develop a 3-D computer code for low gravity fluid dynamic modeling including propellant outflow, venting, reorientation and mixing - FY 1985.
- o Establish oxygen-hydrogen combustor designs capable of transfering high rates of heat transfer to the regenerative coolant (turbine working fluid) - FY 1985.
- o Determine high expansion ratio nozzle performance parameters - FY 1986.
- o Establish the parameters that control the performance level and expected life of advanced OTV engine turbopumps - FY 1986.

JUSTIFICATION:

Technology directed toward extending the capability and versatility of orbital transfer vehicles could contribute significantly to achieving expanded and more economical Earth orbital operations.

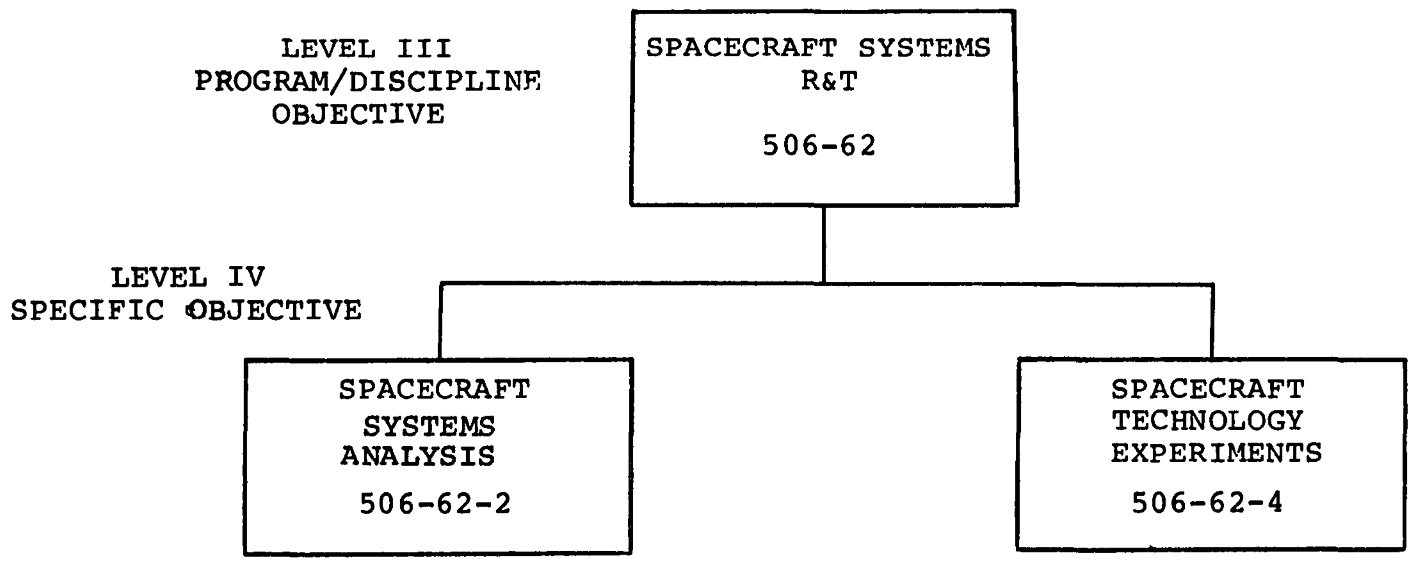
To provide efficient and rapid transfer of men and/or equipment between low Earth orbit and geosynchronous orbit propulsion technology for high thrust (10,000-20,000 lbs.) oxygen-hydrogen systems needs to be extended to achieve high performance over a wide throttling range, multiple restart capability, long operational service life and maintainability, whether the transfer vehicle is space-based or ground-based. These characteristics do not currently exist in today's propulsion systems.

Studies have identified the potential need for vehicles that can carry large, flexible structures from low Earth orbit to geosynchronous orbit. Low-thrust expendable propulsion systems (100-1000 lbs.) can provide a cost-effective method for accomplishing these missions. A technology base for this type of system is lacking and needs to be established.

SPACECRAFT SYSTEMS R&T

SPACECRAFT SYSTEMS R&T WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Spacecraft System R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

PROGRAM/DISCIPLINE OBJECTIVE:

To develop and provide spacecraft technology for large space antenna systems and advanced Earth orbital and planetary spacecraft to support the nation's commercial and scientific objectives in space. This objective is accomplished by identifying spacecraft mission requirements, carrying out system studies, analysis, trades, and simulations, establishing goals and generating discipline and system technology programs requiring analysis, and ground and space experiments.

SPECIFIC OBJECTIVES:

- Spacecraft Systems Analysis: Carry out systems studies, analyses, trades, and simulations for advanced Earth-orbital satellites to support NASA applications, DOD, and high-risk commercial ventures in space; to support large space antenna systems suitable for mobile communications, very long baseline interferometry and radiometry; to support precision deployable structures suitable for submillimeter, infrared (IR) and other large optical systems; and to support planetary aerocapture missions.

- Spacecraft Technology Experiments: Conduct ground and flight system experiments for antenna systems and advanced spacecraft and develop Shuttle space test facilities.

SPECIFIC OBJECTIVE

TITLE: Spacecraft Systems Analysis

Program/Discipline Objective Title: Spacecraft Systems R&T

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

SPECIFIC OBJECTIVE:

Carry out system studies, analyses, trades and simulations for advanced Earth-orbital spacecraft to support NASA science applications, DOD and high-risk commercial ventures in space; to support large space antenna systems suitable for mobile communications, very long baseline interferometry and radiometry; to support precision deployable structures suitable for submillimeter, infrared (IR) and other large optical systems; and to support planetary aerocapture missions.

- Define and implement an advanced Earth orbital system and discipline technology development program.

- Conduct large antenna system studies and analysis to develop systems level technology and define discipline technology goals.

- Carry out system analysis and optical path simulations useful to refine IR/submillimeter concepts and the associated technology program and useful for other large optical systems.

- Achieve orderly conclusion to current planetary aerocapture technology requirements effort. Direct, as appropriate, and under direction of OTV Aeroassist Working Group CH&C activities for optimization of aero-assisted deceleration and maneuvering.

TARGETS:

o Preliminary Spacecraft Technology Plan	FY 1983
o LEO/GEO Spacecraft Analytical Models to Define Accurate Subsystem Requirements	FY 1983
o Define IR/Submillimeter Large Reflector Thermal Control Subsystem Technology Requirements	FY 1983

o Document Planetary Aerocapture Technology Effort for Future Reference	FY 1983
o Spacecraft Analytical Tool to Quantitatively Study Subsystem Interactions	FY 1984
o Definition of Large Radiometer Antenna Technology Requirements	FY 1984
o Enlarge Preliminary Spacecraft System Analysis Capability to Accommodate Precision Deployable Trusses, and Additional Deployable/Assembled Antennas and Advanced Spacecraft	FY 1985
o IR/Submillimeter System Level Proof-of-Concept Experiment	FY 1986

JUSTIFICATION:

In order to maintain the nation's excellence in space, a wide range of advanced spacecraft technologies must be identified, prioritized, and developed. To properly define spacecraft generic technology program goals and plans, systems analyses, trades and simulations must be carried out using advanced spacecraft configured to be representative of many spacecraft being considered for future missions. These required systems analyses develop optimized configurations and provide the technical rationale to guide discipline technology programs operating under budgetary constraints.

SPECIFIC OBJECTIVE

TITLE: Ion Auxiliary Propulsion System

Program/Discipline Objective Title: Space Systems Technology

Responsible Organization/Individual: Space Systems Division/Richard A. Gualdoni

SPECIFIC OBJECTIVE:

To conduct an in-space evaluation of a millipound mercury-ion thruster system over representative duty cycles and time periods; to determine the systems compatibility with the host spacecraft; and to verify the technology readiness of mercury-ion thruster systems for auxiliary propulsion applications aboard operational spacecraft.

- o Conduct a spaceflight experiment as part of the USAF/Space Test Project P80-1 spacecraft.
- o Conduct a ground correlation program to support and facilitate understanding of the flight test results.

TARGETS:

o Ion Auxiliary Propulsion System integration with P80-1 spacecraft	FY 1983
o Launch Readiness	FY 1983 1/
o Complete ground correlation program	FY 1984
o Complete flight program	FY 1986

JUSTIFICATION:

Ion propulsion permits a new generation of spacecraft to allocate less propulsion weight for longer durations at higher orbital maintenance accuracies. It offers significant advantages over chemical propulsion alternatives, namely, higher specific impulse (about 3000 sec., higher by a factor of ten than chemical propulsion), longer life (7-10 years) and lower thrust (1 to 30 mlb).

1/ Launch date controlled by USAF/DOD

The current technology readiness of ion propulsion represents the fruition of many years, beginning in 1968, of technology development. The verification of its potential advantage for mission operations and user acceptance requires flight test verification.

The P80-1 flight opportunity is particularly timely in that auxiliary ion thruster technology is ready for verification. Furthermore, the inexpensive, free-flying, long-duration flight opportunities offered by USAF P80-1 are uncommon and represent a unique opportunity for NASA.

SPECIFIC OBJECTIVE

TITLE: Spacecraft Technology Experiments

Program/Discipline Objective Title: Spacecraft Systems R&T

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

SPECIFIC OBJECTIVE:

Conduct ground and flight system experiments for antenna systems and advanced spacecraft and develop Shuttle space test facilities.

- o Define antenna system and structures/controls flight experiments.
- o Define and develop a low-cost, self-contained and minimum Shuttle interface space testing experiment facility required for a large antenna system structure, controls, and RF experiment, large structures and controls beam experiments and useful for a wide variety of other discipline and system experiments.
- o Conduct system level flight experiments.

TARGETS:

- o Define antenna system and other advanced spacecraft system level flight experiments to advance knowledge in structures, controls, and RF disciplines - FY 1984.
- o Carry out Solar Array Flight Experiment - FY 1984.

JUSTIFICATION:

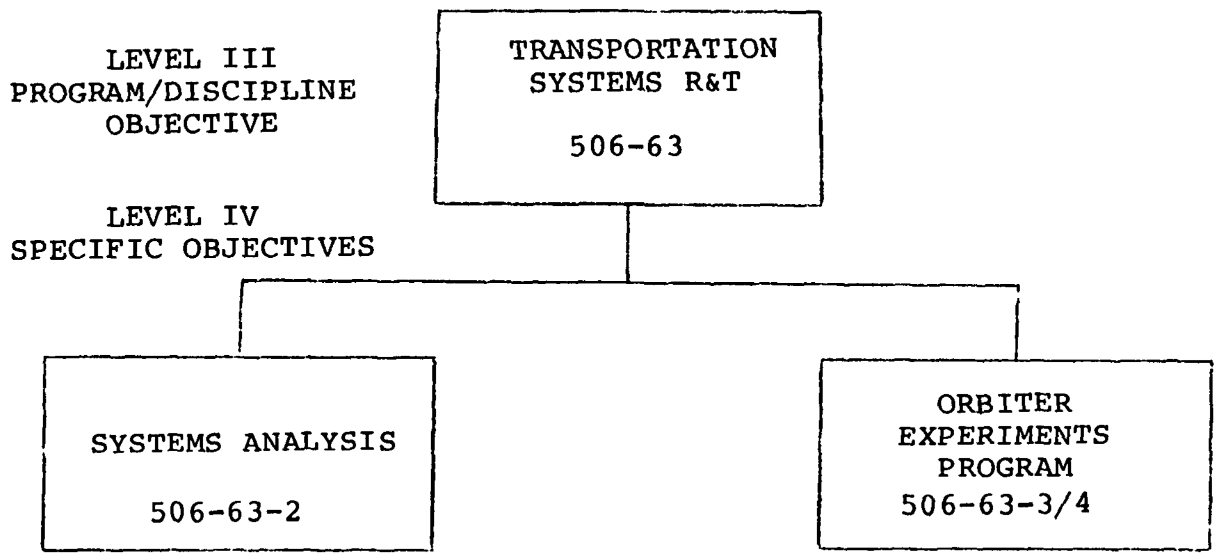
Ground and flight experiments are required in order to accelerate the use of new, difficult, and high-risk technology which holds promise for new capability, greatly improved performance, and reduced costs. This is particularly true in new technologies for distributed control and large, lightweight and flexible structures which support large

antenna systems. This activity fills the void by providing the potential user with data taken from system level experiments carried out in environments which match that of the intended use to the greatest degree possible. This activity also provides the space facilities necessary to support experiments, tests, and demonstrations carried out in space.

TRANSPORTATION SYSTEMS R&T

TRANSPORTATION SYSTEMS R&T WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Transportation Systems R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Edward A. Gabris

PROGRAM/DISCIPLINE OBJECTIVE:

To identify the technology requirements for advanced transportation vehicles to satisfy national needs and then to integrate these requirements into a comprehensive plan that results in transfer-ready technology at the proper time; to advocate the research and technology programs to satisfy these requirements; to conduct the system-level technology programs; and to support the development of the space transportation system (STS) in areas of technical competence. These objectives are accomplished through system-level studies, analyses and requirement definition efforts, discipline and system R&T efforts requiring ground-based facilities, in-space hardware, and instrumentation. Some efforts utilize the Orbiter as an advanced research vehicle.

SPECIFIC OBJECTIVES:

- Systems Analysis: To project and characterize future space transportation needs and capabilities encompassing Earth-to-orbit, orbit-to-orbit, and planetary missions; to conduct technology assessments to identify, justify, and prioritize high-leverage enabling and enhancing technologies; and to provide scope and direction for the R&T program in space transportation.

- Orbiter Experiments Program (OEX): To obtain data on the characteristics of space transportation vehicles which cannot be satisfactorily obtained by analytical techniques using models and computer codes or experimentally in ground-based facilities (such data will be obtained from existing Shuttle flight instrumentation or by special instrumentation developed and integrated into the Orbiter by this program), and to verify the characteristics of advanced transportation hardware in the actual environment to minimize the risk of technology transfer to the flight program.

SPECIFIC OBJECTIVE

TITLE: Systems Analysis

Program/Discipline Objective Title: Transportation Systems R&T

Responsible Organization/Individual: Space Systems Division/James Romero

SPECIFIC OBJECTIVE:

To project and characterize future space transportation needs and capabilities encompassing Earth-to-orbit, orbit-to-orbit, and planetary missions; to conduct technology assessments to identify, justify, and prioritize high-leverage enabling and enhancing technologies; and to provide scope and direction for the R&T program in space transportation.

- Earth-to-Orbit (ETO) Vehicles: To identify high-leverage technologies to enhance the evolutionary growth in space transportation vehicles based on the revolutionary new vehicles projected for the 2000 to 2010 period. Included will be vehicle system efforts to identify and prioritize technologies for a vehicle class, and discipline efforts to define and scope R&T programs.

- Orbital Transfer Vehicles (OTV): To identify the key technologies required for an advanced OTV which will be reusable and space-baseable, and which will have the capability to be recovered via aeroassisted deceleration and maneuvering.

- Planetary Missions: To pursue transportation system technologies consistent with the long-range goals of the planetary program. Specifically, to assess advances in transportation capabilities on the achievability of these goals and to determine the implications of such advances on ETO and OTV requirements.

TARGETS:

o In FY 1983 the program will:

(1) Assess the high-leverage technology recommendations resulting from the Shuttle Derived Vehicle Study to determine the appropriateness for their development at this time relative to the "reality" of a vehicle requirement in the 1990's.

(2) Continue system study efforts for supporting an automation technology program for space transportation vehicles. FY 1983 efforts will focus on mission planning, control, and management.

(3) Start Phase II system analyses and assessment efforts for a future ETO transportation system having an IOC in the post-2000 time frame. Phase II will include optimization of the total transportation system including space station; expand the baseline vehicle concept for payload-to-orbit optimization; determine abort requirements and system design implications; and, funding permitting, expand the structural concepts from the baseline configuration (current state of the art) to include new concepts attainable through technology development.

(4) Continue the system level studies for an advanced aeroassisted OTV which are being conducted under the purview of the Aeroassisted OTV Working Group. The study results achieved in FY 1983 will be used to scope discipline technology programs in FY 1984 (Materials and Structures, controls and guidance, aerodynamics/aerothermodynamics, and propulsion).

JUSTIFICATION:

Improved and new space transportation systems demonstrating improved performance, versatility, and cost effectiveness over the current capability baseline will be required to efficiently satisfy requirements beyond 1990. Because the lead time required to bring the necessary high-leverage technologies to the required readiness state for transfer is long (demonstrated to be as much as 10 years in chemical propulsion and materials science), it is necessary to initiate efforts for future

applications at this time. This specific objective will focus on the essential tasks (based on cost benefit, technical feasibility, and schedule considerations) identified in system analyses and technology assessments and endorsed by the Advanced Space Transportation Technology Working Group and external consultants.

SPECIFIC OBJECTIVE

TITLE: Orbiter Experiments Program (OEX)

Program/Discipline Objective Title: Transportation Systems R&T

Responsible Organization/Individual: Space Systems Division/Michael Cuviello

SPECIFIC OBJECTIVE:

To obtain data on the characteristics of space transportation vehicles which cannot be satisfactorily obtained by analytical techniques using models and computer codes or experimentally in ground-based facilities (such data will be obtained from existing Shuttle flight instrumentation or by special instrumentation developed and integrated into the Orbiter by this program), and to verify the characteristics of advanced transportation hardware in the actual environment to minimize the risk of technology transfer to the flight program.

- o Project Management: Provide the overall project management for the Orbiter Experiments program and the interface functions necessary to assure the integration of experiments into the Shuttle vehicle. Provide for the storage, cataloging, and dissemination of Development Flight Instrumentation and Operational Instrumentation and Orbiter experiments data of potential interest to reseachers for advanced research and technology investigations.

- o Aerodynamic Research: Develop instrumentation for the collection of aerodynamic research-quality data necessary for the verification of analytical and ground-based facility simulation and test techniques.

    - Aerodynamic Coefficient Identification Package: Provides vehicle inertial attitude and rate information for extraction of aerodynamic coefficients.

    - Shuttle Entry Air Data Systems: Provides vehicle free-stream air data measurements necessary to calculate angle of attack, yaw angle, and Mach number.

- Shuttle Upper Atmosphere Mass Spectrometers: Provide a mass spectrometer for the measurement of free-stream density in the free molecules flow regime.

- Shuttle Altitude Measurement System: Provides accurate measurement of vehicle altitude for trajectory reconstruction.

o Aerothermodynamic Research: Develop instrumentation for collection of research-quality data necessary for determination of vehicle surface temperature distribution during entry. Data will advance the understanding of vehicle flow-field patterns and aid in the optimization of thermal protection system designs for future transportation systems.

- Infrared (IR) Imagery of Shuttle: Provides vehicle windward surface temperature distribution through the use of an airborne IR telescope.

- Shuttle Infrared Leeside Temperature Sensing: Provides leeside surface temperature distribution using an IR camera mounted atop the Orbiter vertical tail.

o Thermal Protection Systems: Develop instrumentation and techniques to obtain in-flight data on thermal protection characteristics, and develop flight demonstrations and verification of advanced thermal protection system concepts.

- Tile Gap Heating: Provide tile panels and instrumentation for the evaluation of the heating effects of various tile gap configurations.

- Catalytic Surface Effects: Provide catalytic coating material and instrumentation for the evaluation of catalytic surface efficiency on convective heating.

- Nonmetallic TPS: Develop the hardware flight demonstration and evaluation of advanced nonmetallic thermal protection systems.

o Structural Systems:

- Dynamic, Acoustic, & Thermal Environments: Provide instrumentation for the collection of research-quality data of flight environments and the effects on structural components for the verification of predictive models.

o Materials:

- Advanced carbon-carbon (ACC): Validate through flight demonstration the use of thin-section ACC.

TARGETS:

The flight targets are:

o Infrared Imagery of Shuttle	FY 1982/83	(STS-4/5)
o Thermal Protection Systems (Tile Gap & Catalytic Surface)	FY 1982/83	(STS-4/5)
o Aerodynamic Coefficient Instrumentation Package	FY 1982/83	(STS-4/5)
o Dynamic, Acoustic, & Thermal Environments	FY 1982/83	(STS-4/5)
o Shuttle Entry Air Data System	FY 1983/84	(STS-9)
o Shuttle Infrared Leeside Temperature Sensing	FY 1983/84	(STS-9)
o Shuttle Upper Atmosphere Mass Spectrometer	FY 1983/84	(STS-9)
o Nonmetallic TPS	FY 1986	
o ACC	FY 1986	

JUSTIFICATION:

The Space Shuttle provides an unprecedented opportunity to obtain data on the characteristics of space transportation vehicles which cannot be satisfactorily obtained either analytically or in ground-based facilities. These data are essential to increasing many performance capabilities of the current Shuttle system and will have a significant impact on the design of future more advanced vehicles. The ability to obtain such in-situ data will be a significant factor in planning OAST's R&T program in the transportation area.

PLATFORM SYSTEMS R&T

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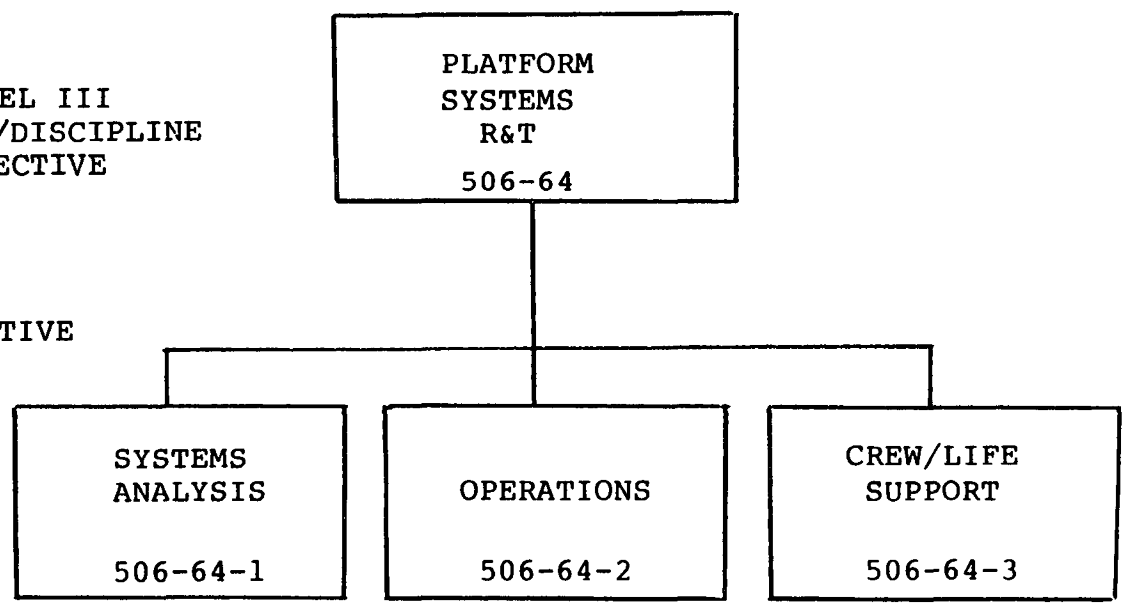
PLATFORM SYSTEMS R&T WORK BREAKDOWN STRUCTURE
LEVELS III & IV

LEVEL III
PROGRAM/DISCIPLINE
OBJECTIVE

LEVEL IV
SPECIFIC OBJECTIVE



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Platform Systems R&T

Program Area Title: Research and Technology Base

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

PROGRAM/DISCIPLINE OBJECTIVE:

To identify the technology requirements and conduct generic systems and discipline advanced technology programs that support Agency platform and space station thrusts for permanent occupancy of space. To provide integrated system and discipline programs that maximize technology options, allow for modular evolutionary growth capability with new technology and satisfy national needs for improved performance missions while minimizing life cycle costs. To establish a coordinated technology program across all disciplines that will produce appropriate levels of transfer ready technology phased with mission needs. To identify and define requirements for ground and in-space tests and experiments including facilities, instrumentation, and hardware/software to validate system and discipline performance and analytical methods.

SPECIFIC OBJECTIVES:

- Systems Analyses: To perform systems analysis and interdiscipline interaction/sensitivity studies to define technology drivers and priorities for high-leverage discipline technology programs. To develop systems analysis/optimization techniques across disciplines and systems configurations for evolutionary modular growth with advanced technology. To define and develop technology for automated system self-test/monitoring, environment interaction and crew escape and rescue.

- Operations: To provide operations technology to support on-orbit construction/assembly, checkout, rendezvous, docking and proximity operations, logistics, and maintenance and servicing. To define automation requirements and automated systems to optimize space and ground operations and provide capability for evolutionary systems growth.

- Crew/Life Support: To develop crew and life support water regenerative and air revitalization technology to establish permanent human presence in space.

SPECIFIC OBJECTIVE

TITLE: Systems Analyses

Program/Discipline Objective Title: Platform Systems R&T

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

SPECIFIC OBJECTIVE:

To perform systems analyses and interdiscipline interaction/sensitivity studies to define technology drivers and priorities for high-leverage discipline technology programs. To develop systems analysis/optimization techniques across disciplines and systems configurations for evolutionary modular growth with advanced technology. To define and develop technology for automated system self-test/monitoring, environment interaction and crew escape and rescue.

TARGETS:

- Develop Generic Space Station Model, and Interactive Subsystem Optimization Modules, and Define Key Space Station Configuration Parameters — FY 1983
- Perform Systems Study to Develop Automation Technology Required for Multihundred kW Power Systems in Orbit — FY 1983
- Determine Requirement for an Agencywide Contamination Data Base, Determine User Community, i.e., Within Agency, DOD, and Industry, and Define Content of a Data Base to Meet User Community Requirements — FY 1983
- Define Propulsion Requirements of a Shuttle-Serviced Manned Space Station in Low Earth Orbit Including the Advantages and Disadvantages of Propulsion-Related Operating Options — FY 1983
- Develop Automation Assessment Methodology and Define Hierarchical Systems Automation Requirements for Automated Subsystem Control/Management — FY 1984

- o Perform System and Discipline Analysis/Trade Studies to Develop Generic Requirements for Platform Systems — FY 1984

- o Develop Life Cycle/Technology Cost Benefit Analytical Capability — FY 1984

- o Define Requirements for Automated Systems Status Monitoring and Integrated Subsystem Techniques for Fault Detection, Isolation, and Recovery — FY 1984

- o Define System/Subsystem Interface Architecture Requirements to Optimize Evolutionary Growth — FY 1985

- o Define Requirements for Crew "Safe Haven" Retreat and Transfer to Rescue Vehicle — FY 1985

- o Determine Space Station Automation Requirements

  - Determine Level of Automation On-Board/Ground — FY 1986

  - Determine Human Role in Automation — FY 1986

  - Define Optimum Human/Hardware Mix — FY 1987

JUSTIFICATION:

In order to plan effective space station technology programs, systems analyses and studies must be conducted to determine sensitivities between subsystems and to define key configuration parameters. The studies are iterative and utilize discipline technology inputs and requirements to provide technology options that are optimized for key parameters. High-leverage discipline technologies are defined and prioritized for optimum life cycle cost/technology benefit.

SPECIFIC OBJECTIVE

TITLE: Operations

Program/Discipline Objective Title: Platform Systems R&T

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

SPECIFIC OBJECTIVE:

To provide operations technology to support on-orbit construction/assembly, checkout rendezvous, docking, and proximity operations, logistics, maintenance, and servicing. To define automation requirements and automated systems to optimize space and ground operations and provide capability for evolutionary systems growth.

TARGETS:

o Complete the Preliminary Design of Experiments for Studying the Gravity Effects of Pool Boiling, Forced Convection Boiling, and Liquid Reorientation (Settling)	FY 1983
o Define Requirements for Deployment, Mating, and Checkout for Initial Space Station Placement and Define Shuttle/ Station Rendezvous and Docking Requirements and Techniques	FY 1984
o Develop Simulations for Rendezvous and Docking Maneuvers and Define Requirements and Techniques for Caution and Warning/Collision Avoidance	FY 1985
o Complete the Detailed Design of the Cryogenic Fluid Management Facility (CFMF) which will serve as a Reusable Test Bed for Generating Technology for the Storage, Acquisition, and Transfer of Liquid Cryogens in Space and Evaluate Refrigeration Systems for Application to Long Term Storage of Hydrogen	FY 1985

JUSTIFICATION:

The space station is being developed for operations in space. Operations technology cuts across every aspect of space station technology development, both on the ground and in space. Operations must be considered in conjunction with other advanced technologies in order to incorporate operations requirements in systems and discipline programs. This will provide for evolutionary growth capability compatible with system and subsystem advanced technology development. Operations technology programs integrated with discipline technologies are a key to minimizing life cycle costs. The overall success of space station requires operations planning, and technology development directed at operational efficiency for minimum cost.

SPECIFIC OBJECTIVE

TITLE: Crew/Life Support

Program/Discipline Objective Title: Platform Systems R&T

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

SPECIFIC OBJECTIVE:

Develop space station crew/life support water regeneration and air revitalization technology to support the establishment of permanent human presence in space.

- o Develop Crew/Life Support Technology to Support Initial Space Station Design
- o Develop Crew/Life Support Technology for Later Space Station Subsystem Retrofits

TARGETS:

o Develop CO_2 Concentrator Unit Technology, Preprototype Unit/Prototype Unit	FY 1983/1984
o Develop O_2 Water Electrolysis Unit	FY 1984
o Develop Water Reclamation Technology	FY 1985
o Develop N_2 Generation Based on Hydrazine Decomposition Process, Preprototype Unit/Prototype Unit	FY 1984/1986
o Complete Manned Ground Chamber Test of a Prototype Partially Closed-Loop Life Support System	FY 1986
o Develop Technology for Supercritical Waste Oxidation Process	FY 1989

JUSTIFICATION:

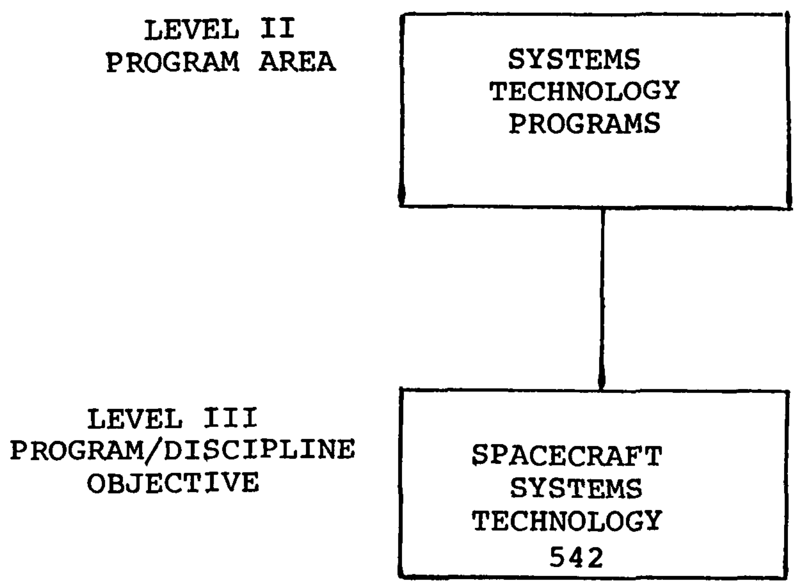
Large quantities of air and water will be consumed by space station occupants over periods of many years in space. On the supply side, this places great and expensive demands on space Shuttle payloads delivered to space station and, on the disposal side, creates a severe orbital contamination problem. Regenerative crew/life support systems would require only an initial supply of consumables and much less resupply, and can provide solutions to these problems through efficient water reclamation technology development and air revitalization technology development which would also eliminate and/or reduce the contamination problem.

SYSTEMS TECHNOLOGY PROGRAMS

14

SYSTEMS TECHNOLOGY PROGRAMS WORK BREAKDOWN STRUCTURE

LEVELS II & III



PROGRAM AREA GOAL

TITLE: Systems Technology Programs

Program Goal Title: Space Research and Technology

PROGRAM AREA GOAL:

To provide technology for systems which have matured under the Research and Technology Base; to carry the innovative systems through experimental testing and verification in a realistic environment; to design, fabricate and test multidisciplinary concepts in the space environment, thereby reducing the technical risk and qualifying the technology concept for use on future missions; and to develop major research payloads for future missions.

PROGRAM/DISCIPLINE OBJECTIVE:

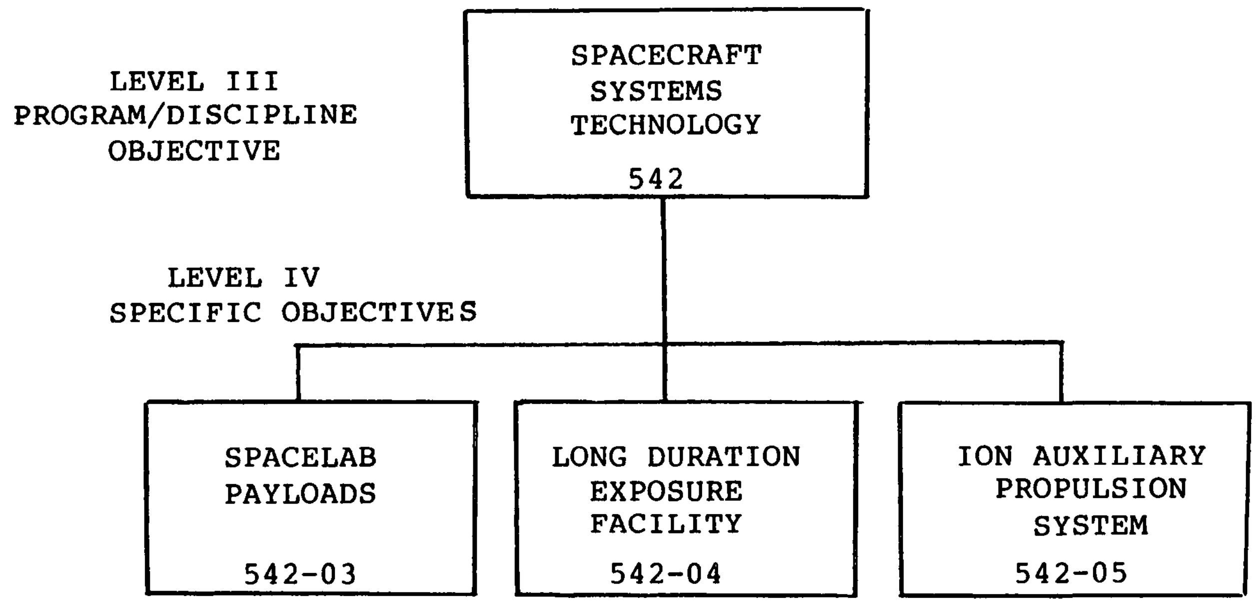
- Spacecraft Systems Technology: To provide for the verification/demonstration of space discipline and systems technologies through flight and/or ground-based experiment programs.

SPACECRAFT SYSTEMS TECHNOLOGY

15

SPACECRAFT SYSTEMS TECHNOLOGY WORK BREAKDOWN STRUCTURE

LEVELS III & IV



PROGRAM/DISCIPLINE OBJECTIVE

TITLE: Spacecraft Systems Technology

Program Area Title: Systems Technology Programs

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

PROGRAM/DISCIPLINE OBJECTIVE:

To provide for the verification/demonstration of space discipline and systems technologies through flight and/or ground-based experiment programs.

SPECIFIC OBJECTIVES:

- Spacelab Payloads: To develop, implement, and fly, in accordance with approved project plans, those Spacelab experiments which have been selected as part of the OAST Payloads program.

- Long Duration Exposure Facility (LDEF): To develop a free-flying facility for conducting long-term, exposure-type experiments for the first LDEF flight; to deploy and recover the first LDEF; and to prepare preliminary reports on the experiment results.

- Ion Auxiliary Propulsion System: To conduct an in-space evaluation of a millipound mercury-ion thruster system over representative duty cycles and time periods; to determine the systems compatibility with the host spacecraft; and to verify the technology readiness of mercury-ion thruster systems for auxiliary propulsion applications aboard operational spacecraft.

SPECIFIC OBJECTIVE

TITLE: Spacelab Payloads

Program/Discipline Objective Title: Spacecraft Systems Technology

Responsible Organization/Individual: Space Systems Division/Richard F. Carlisle

SPECIFIC OBJECTIVE:

To develop, implement, and fly, in accordance with approved project plans, those Spacelab experiments which have been selected as part of the OAST Payloads program.

- Drop Dynamics Module: To develop an acoustic positioning and control system for conducting drop dynamics experiments in a Spacelab; to develop the fundamental set of experiments and organize a competent scientific constituency; and to conduct the fundamental experiments on an early Spacelab mission.

- Induced Environment Contamination Monitor: To develop a self-contained contamination monitor which satisfies the measurement requirements specified by the Particles and Gases Contamination Panel and the Space Transportation System Payload Contamination Requirements Definition Group; and to fly the monitor on the Development Flight Instrumentation Pallet during Orbital Flight Test (OFT) missions.

- SEPS Solar Array: To demonstrate the readiness of solar array technology. Specifically, to determine the in-space dynamic properties of the array and to obtain structural dynamic data which will be valuable in developing a theoretical and analytical capability to predict the behavior of large space structures; to establish the electrical and thermal performance characteristics; and to demonstrate deployment/stowage characteristics of this large space structure.

- o Superfluid Helium Experiment: To study the fundamental properties of superfluid helium in a zero-gravity environment. Specifically, to measure the low-frequency slosh modes; to measure the temporal and spatial fluctuations of temperature; and to demonstrate the existence of low-frequency quantized surface waves in the films.

- o Feature Identification and Location Experiment (Reflight): To collect a broad sample of statistical data under diverse lighting conditions and cloud cover; to verify the accuracy of discrimination between Earth features (bare Earth, vegetation, water, and clouds/snow/ice) from low Earth orbit; and to optimize sensor gains and thresholds.

- o Solar Cell Calibration Facility: To develop a facility which will accommodate the in-space calibration of solar cells.

- o Tribology Experiments in Zero-Gravity: To determine the zero-gravity effects on the hydrodynamic films formed in journal bearings; to measure the spreading rates of lubricants in a zero-gravity environment; and to determine the extent to which lubricant wetability is affected by this environment.

- o Semiconductor Materials Growth in Low-G Environment: To obtain superior semiconductor material by utilization of the low-g environment of the Shuttle to minimize the segregation of the constituents and to minimize the influences of thermal convection.

TARGETS:

The target flight readiness dates are:

	Mission
o Induced Environment Contamination Monitor	STS-1-4, SL 1&2
o Feature Identification and Location Experiment (Reflight)	OSTA-3

- Solar Cell Calibration Facility — OAST-1
- Superfluid Helium Experiment — SL-2
- Tribology Experiments — SL-1
- Drop Dynamics Module — SL-3
- Semiconductor Materials — SL-3
- SEPS Solar Array Experiment — OAST-1

JUSTIFICATION:

The program provides the means for extending OAST's research and technology into the space environment when the logical progress of an R&T effort requires an in-space test to obtain access to a unique space parameter, when an in-space test is cost-effective compared to ground-based facilities, or when an in-situ demonstration of technology accelerates the utilization of technology by the ultimate user.

Experiments are selected in accordance with NMI 8030.5A. The experiment identification and selection process encourages, in addition to proposals from within NASA, proposals from the industrial and academic community thus providing this important segment of the scientific community access to the unique environment of space for the conduct of research and technology.

SPECIFIC OBJECTIVE

TITLE: Long Duration Exposure Facility (LDEF)

Program/Discipline Objective Title: Spacecraft Systems Technology

Responsible Organization/Individual: Space Systems Division/Richard A. Gualdoni

SPECIFIC OBJECTIVE:

To develop a free-flying facility for conducting long-term, exposure-type experiments for the first LDEF flight; to deploy and recover the first LDEF; and to prepare preliminary reports on the experiment results.

- o Develop the LDEF--a simple, low-cost, recoverable, reusable, free-flying facility for conducting generally passive experiments which require long-term exposure in the space environment.
- o Select the experiment complement and develop those which are consistent with OAST research and technology objectives. (Experiments in other disciplines will be developed by the appropriate program office.)
- o Deploy LDEF from the Orbiter; recover it six to twelve months later; and return the experiments to the investigators for analysis at the laboratories of origin.
- o Prepare preliminary reports on the results of those experiments developed by OAST.

Experiments will be obtained via three methods: direct selection of technology experiments which complement and support OAST research and technology programs (NMI 8030.5A); Announcements of Opportunity to solicit and select experiments from a broad community (NMI 7100.13); and Memoranda of Agreement to obtain experiments on a no-cost-to-OAST basis from other NASA program offices, other government agencies, and non-government organizations.

TARGETS:

- o Experiment Delivery Complete FY 1983
- o LDEF Delivery to Kennedy Space Center FY 1983
- o Launch Readiness FY 1984
- o Preliminary Data Analysis and Reporting TBD*

JUSTIFICATION:

To obtain data on the combined long-term effects of the space environment on materials, components, and processes (physical and biological), it is necessary to conduct experiments in the space environment. The LDEF provides this capability, which complements the capabilities of ground-based research facilities which either cannot obtain such data or can do so only at much greater cost.

LDEF provides a significant opportunity to the scientific and technical community to include space as part of their research and technology programs by offering a low-cost approach to extending these programs into space. The experiments are simple and generally passive and, because the experiment is returned to the investigator for analysis, the need for sophisticated data-collecting instrumentation is eliminated.

* Will be based on LDEF retrieval date.